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DESIGN AND CONSTRUCTION OF TEST FACILITIES TO SIMULATE THE EFFECTS OF A NUCLEAR DETONATION HANDEC I AND HANDEC II

Howard L. Taylor, CCE
The Bob Rutherford Consrruction Company

TECHNICAL REPORT NO. AFWL-TR-69-171

May 1970

AIR FORCE WEAPONS LABORATORY
Air Force Systems Command
Kirtland Air Force Base
New Mexico

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119

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FOREWORD

This report was prepared by the Bob Rutherford Construction Company, Albuquerque, New Mexico, under Contract F29601-69-C-0047. The research was performed under Program Element 65701H, Project 5710, Subtask SD 162, and was funded by the Defense Atomic Support Agency (DASA).

Inclusive dates of research were January 1969 to September 1969. The report was submitted 27 February 1970 by the Air Force Weapons Laboratory Project Officer, Captain Philip L. Madden (WLCD).

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This technical report has been reviewed and is approved.

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ABSTRACT

(Distribution Limitation Statement No. 2)

A method of simulating the effects of the static overpressure of the airblast and the resulting airblast-induced ground motions associated with a nuclear blast was developed by the Air Force Weapons Laboratory, and was designated High Explosive Simulation Technique (HEST). Recently, the Air Force Weapons Laboratory has been conducting tests to simulate the direct-induced ground shock from a nuclear detonation and has designated this simulation as Direct Induced High Explosive Simulation Technique (DIHEST). Proposed construction of new, harder weapon systems in rock sites made it desirable to apply the HEST and DIHEST method to simulate these environments. This report describes the design and construction of both the HANDEC I and HANDEC II test facilities that were constructed in rock located near Cedar City, Utah. Design criteria are stated, some unique construction methods used are described, and recommendations are made for application to future similar projects. A complete set of design drawings and construction photographs are included. The Air Force conducted the tests and analyzed the results. This phase of the project is described in another AFWL technical report and is not included herein.

CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (cont'd)

ILLUSTRATIONS (cont'd)

ILLUSTRATIONS (cont'd)

ILLUSTRATIONS (cont'd)

ILLUSTRATIONS (cont'd)

ABBREVIATIONS

ACI	American Concrete Institute
AFSWC	Air Force Special Weapons Center
AFWL	Air Force Weapons Laboratory
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
CERF	Civil Engineering Research Facility
GFP	Government Furnished Property
COE	Corps of Engineers, United States Army
HEST	High Explosive Simulation Technique
DIHEST	Direct Induced High Explosive Simulation Technique
TR	Technical Report
UBC	Uniform Building Code

SECTION I

INTRODUCTION

The United States Air Force has been assigned the responsibilities for conducting simulated nuclear tests on operational hardened systems, for basic research on nuclear weapons effects and for providing information relative to these effects for use in designing future hardened systems. The Nuclear Test Ban Treaty of August 1963 made it necessary to develop a capability to simulate nuclear weapons effects. The Civil Engineering Branch of the Air Force Weapons Laboratory (AFWL) responded with a program that developed the High Explosive Simulation Technique (HEST), a technique that simulates the peak static overpressure of the airblast and the resulting airblast-induced ground motions from a nuclear detonation for certain overpressure ranges and for certain yield weapons. Recently, the Air Force Weapons Laboratory has been conducting studies and field tests to simulate the direct-induced ground shock resulting from a nuclear detonation and has designated this simulation as Direct Induced High Explosive Simulation Technique (DIHEST).

A redirection of effort, prompted by the development of newer, harder structures for a new family of missile facilities has resulted in a program to apply the HEST and DIHEST technique to a rock site. These projects, designated HANDEC I and HANDEC II Development Experiments, were performed at a test area, located approximately 17 miles northwest of Cedar City, Utah. The testing was a combined AFWL and contractor effort. The HANDEC I facility was designed by AFWL while the HANDEC II design was provided by the prime contractor. The contractor performed all construction tasks. The test facilities, including the construction of six test structures

(research models) on HANDEC 1 and nine test structures on HANDEC II, were built to AFWL provided parameters. The test objectives were: (1) to produce an overpressure and an air-blast-induced ground motion environment; (2) simulate a ground shock wave similar to that produced by the cratering force of a nuclear explosion as specified by the Air Force Weapons Laboratory (AFWL) in a rock media; (3) test the time phasing of HEST and DIHEST; (4) test an instrumentation system in protective piping in a multiple ground shock environment; (5) test anchored surface instrumentation cable pipe systems versus cable in a trench excavation in rock, with protective pipe that was sand enclosed and concrete capped; and (6) test a split pipe cable protection system which was also sand enclosed and concrete capped.

The major simulated airblast parameters were peak overpressure level, shock-front velocity, overpressure duration, pulse shape and total impulse. Simulated direct-induced ground shock parameters were peak velocity and peak transient displacements. The HANDEC I and HANDEC II tests were fired with a 54 and 42.5 millisecond delay respectively between the HEST and DIHEST explosions to allow the two shock waves to be induced into the rock with timing similar to that of a specified yield nuclear explosion. The achievement of specific airblast effect phenomena required the construction of a supporting structure on rock. Earth overburden was compacted to a specified density against the exterior concrete walls of each test facility and over the structural steel supports of the test facility structure. Each test facility structure was instrumented with strain gages to verify structural design and integrity of the facility during surcharge loading. Detonating cord was installed in the test cavity of each test facility in specified amounts and configurations such that when detonated,

a shock wave would propagate throughout the cavity at the design velocity. The peak overpressure was contained for sufficient time by the overburden and surcharge support structure, which provided a reactive force to shape the resulting pulse wave and to lengthen its duration. The DIHEST portion of the HANDEC I test consisted of eleven holes, 9 inches in diameter, at 10 feet o.c. These holes formed a 100-foot line parallel to and located 25 feet from the inside face of the test facility concrete wall. Explosives for each hole consisted of ten 40-pound ammonium nitrate cannisters in each hole, located at elevation minus 13 feet from the test facility floor and then 4 feet on center thereafter to elevation minus 49 feet, giving a total explosive of 4400 pounds. These charges were grouted in place by AFWL personnel. No additional berm was provided over the DIHEST explosives. The DIHEST portion of the HANDEC II test involved placing conventional explosives in 29 holes 12 inches in diameter and spaced on 7 feet - 2 inch centers. These holes formed a 200-foot line parallel to and located 96 feet from the inside face of the test facility wall and extended approximately 70 feet below test bed elevation. Explosive used was Ireco DBA-22M, an aluminum ammonium nitrate slurry. A total of 92,440 pounds of explosive was used in the 29 holes. To reduce rock ejecta, an earth berm was constructed 60 feet wide by 290 feet long, in plan, directly over the 29 holes with side slopes of 1 1/4 to 1. Berm height was approximately 50 feet above test bed elevation as shown on Figure 91.

The end result of these tests was the collection of data relating to blast and shock wave effects on structures, materials and instrumentation gages. Instrumentation in the form of sensors was located in and around the cavity to record the blast effects of the wave propagation through the rock material. Sensors included displacement gages, velocity gages,

pressure gages, strain gages, accelerometers, and time-of-arrival crystals. Instrumentation sensor data was transmitted to a centralized trailer area and recorded for later analysis by AFWL personnel. Instrumentation totaled approximately 600 active channels for both tests plus passive measurements as specified by the AFWL document "HANDEC I and HANDEC II Structural Measurement List." All instrumentation for HANDEC I and HANDEC II was designed, procured, and installed by technicians from the Air Force Weapons Laboratory, Special Weapons Center and the E. H. Wang Civil Engineering Research Facility. Drilling services for instrumentation installation was provided by the U. S. Army Corps of Engineers, Mobile District, Mobile, Alabama, under AFWL direction.

SECTION II

DESIGN CRITERIA - HEST - DIHEST TEST FACILITIES

	Criteria	HANDEC I	HANDEC II
1.	Design Services - Plans & Specifications	AFWL	Contractor
2.	Test Facility - Plan Dimension	60 feet wide x 40 feet long	90 feet wide x 60 feet long
3.	Test Facility - Height Test Bed Floor to Bottom of Beams	6 feet	5 feet
4.	Surcharge Loading	3000 psf ± 100 psf	2000 psf ± 100 psf
	Approximate Height	30 feet	20 feet
5.	Test Facility - Walls	One-foot thick reinforced concrete	One-foot thick reinforced concrete
6.	Girders	Structural steel	Structural steel
7.	Columns	Structural steel	Structural steel
8.	Bracing	Structural Steel	Structural steel
9.	Decking	Steel - commercially available	Steel - commercially available
10.	Berm Configuration	Height of the surcharge by 30 feet wide at the top with side slope of 1 foot vertical to 1 1/2 foot horizontal	Height of the surcharge by 30 feet wide at the top with side slope of 1 foot vertical to 1 1/2 foot horizontal
11.	Berm Compaction	95 percent of modified AASHO	95 percent of modified AASHO

	Criteria	HANDEC I	HANDEC II
12.	Bearing for Enclosure Wall & Structural Steel Columns	Rock test bed	Rock test bed
13.	Columns over Test Structures	Omit nuts on anchor bolts	Omit nuts on anchor bolts
14.	Detonating Cord	Government-furnished 400 grain per foot	Government-furnished 400 grain per foot
15.	Detonating Cord Mounting	Wood racks	Wood racks
16.	Peak Overpressure	6000 psi	3000 psi
17.	Weapon Simulated	10 megaton	1.5 megaton
18.	Weave Angle	53°	36°
19.	Detonating Cord (Approximately)	340,000 feet	380,000 feet
20.	Number of Layers of Racks Installed in the Cavity	9	5
21.	Planewave Generator Penetrations in Concrete Wall	8	12
22.	Instrumentation Plan	AFWL	Provided by AFWL to the contractor for inclusion in the final design plans at the time of initiation of design
23.	Trenching Plan	AFWL	Provided by AFWL to the contractor for inclusion in the final design plans at the time of initiation of design

Criteria	HANDEC I	HANDEC II
24. Cable Protection System	AFWL	Provided by AFWL to the contractor for inclusion in the final design plans at the time of initiation of design
25. Metal Storage Building	None	40 feet by 100 feet metal storage building with interior lighting and doors at each end
26. Secondary Electrical System	Performed by AFWL	Secondary distribution system for electrical power to supply all instrumentation trailer and utility requirements Extension of electrical 208 and/or 120 vrms power from the main power panel to five outlying areas

SECTION III

HANDEC I DESIGN PHILOSOPHY

Because of the temporary nature of this facility, the following design criteria were used for the HANDEC I test facility designed by the Air Force Weapons Laboratory, Civil Engineering Branch, Kirtland Air Force Base, New Mexico.

(1) Plastic design for steel beams with a load factor of 1.25.

(2) Elastic design for columns.

(3) Ultimate strength design for reinforced concrete with a load factor of 1.0.

(4) Elastic design for steel deck and subdeck.

All vertical and lateral loads were assumed to be uniform over and around the entire structure.

Footings were not required under columns because the bearing capacity of the rock was adequate to support the loads. Columns were dry-packed on the rock base. Lateral column support was obtained by anchor bolts drilled and grouted directly into the rock as shown on Figure 72. Base plate thickness required by design was 1 3/8 of an inch. Column design by the elastic method required 6-inch wide flange 20 pound columns.

Beam design lengths were based on a 4-span condition (31 feet - 0 inch). Splice points were located over columns. Beam design required fourteen wide flange 30 pound beams, as shown on Figure 72.

Subdecking was supported on the lower flanges of the beams to provide a smooth ceiling in the cavity. Twenty-four gage corruform was used as shown by Figure 72. Fourteen inches

of earth fill was then placed over the subdecking to permit welding structural decking to the structural steel frame.

Roofdeck design was based on a minimum deck length of 12 feet (3 span lengths). Elastic analysis was used for design.

Perimeter wall construction was reinforced concrete and designed to support lateral loads. Walls spanned vertically from the test bed floor to a bond beam at the top as shown on Figure 72. The lateral reaction at the bottom of the wall was resisted by friction and the No. 9 dowels on 3-foot centers drilled into the rock as shown on Figure 72.

HANDEC II DESIGN PHILOSOPHY

Because of the temporary nature of this facility, conservatism in design was not desired. The requirement was to design a structure that would be just adequate to support the imposed loads with a reasonable factor of safety against failure. The statement of work specified design would be by the plastic analysis method and that design in accordance with standard building codes was <u>not</u> required.

The following design criteria were used for the HANDEC II test facility:

(1) Plastic design for steel beams with a load factor of 1.25.

(2) Elastic design for columns.

(3) Ultimate strength design for reinforced concrete with a load factor of 1.0.

(4) Elastic design for steel deck and subdeck.

(5) A 25 percent increase over the allowable AISC values for high strength bolted connections and a 50 percent increase over the allowable uniform building code values for shear on anchor bolts.

All vertical and lateral loads were assumed to be uniform over and around the entire structure. Unbalanced vertical loads were not considered. The plastic analysis of continuous beams does not require the usual "checkerboard" loading of spans, since the load-carrying capacity of any one span is not a function of the load on adjacent spans.

To expedite erection, one-bolt connections were used on double angle struts as shown on Figure 92. The roofdeck was welded to the steel beams by the "MIG Inert Semi-Automatic process" employing the "burn-through" method. All structural steel connections were bolted to minimize field welding.

Footings were not required under columns because the bearing capacity of the rock was sufficient to support the loads imposed. Therefore, columns were dry-packed directly to the rock floor. These columns were supported laterally by anchor bolts drilled and grouted directly into the rock.

Base plate thickness required by design was much less than that used, based on an allowable rock bearing pressure of 10,000 psi. In the exercise of engineering judgment, however, a minimum thickness of three-quarters of an inch was used based on a maximum bending stress of 36,000 pounds per square inch, the yield stress of A-36 steel.

Column design was most economical when based on the elastic method because the unsupported column length was so small. Plastic design would have required a thicker flange than elastic design because of the flange width-to-thickness requirements of plastic design which should be equal to or less than 17. Actual flange width to thickness used with elastic design was 22. Because the test bed floor was not level, a survey was required to determine the floor elevation at each column location.

Beam design lengths were based on a 4-span condition (30 feet - 0 inch). Splice points were located over columns in order to avoid complicated moment connections. Strut action was relatively small and did not reduce the plastic moment capacity of the section. Also, the two-bolt connection at the splice was sufficient to transfer the lateral load through the cap plate (see Figure 92); therefore, beam continuity was not required. Compression flanges were supported laterally at plastic moment locations by the roofdeck at mid-span, and by the double angle struts and stiffeners at the columns. Beam stiffeners at the columns were required in plastic design

because the section proposed fell just short of the flange width to thickness requirements. However, the beam stiffeners did serve other functions, such as transferring the double angle strut load and preventing lateral beam roll when placing fill over the subdeck and surcharge over the decking. The plastic failure mechanism in this design analysis is the development of plastic hinges at the first interior support and at a distance of 3.41 feet from the end support. Maximum shear occurs at the exterior side of the first interior support as shown on Figure 1. At this location, the web shear capacity of the unreinforced section is reached prior to the full development of both plastic hinges. Neglecting the web doubler plates (stiffeners) at the supports, the factor of safety in shear would have been only 1.14. It was decided that this was too low and the section was reinforced at these critical shear locations by web doublers as shown on Figure 92. This increased the factor of safety to a desired 1.25.

The subdeck was supported on the lower flanges of the beams to provide a flush smooth ceiling in the cavity and to provide support for the earth fill shielding the HEST explosive from welding operations on the structural deck. No connections were provided at supports, as shown by Figure 92. Ten-inch earth fill was then added and proved adequate protection for the detonating cord underneath during the welding of the roofdeck to the structural steel beams.

Roofdeck design was based on a minimum deck length of 5-spans or 20 feet. Elastic analysis indicated that web crippling at supports was the governing factor in design. Design in this area was according to the AISI, with the allowable bending stress equal to the yield stress of the material.

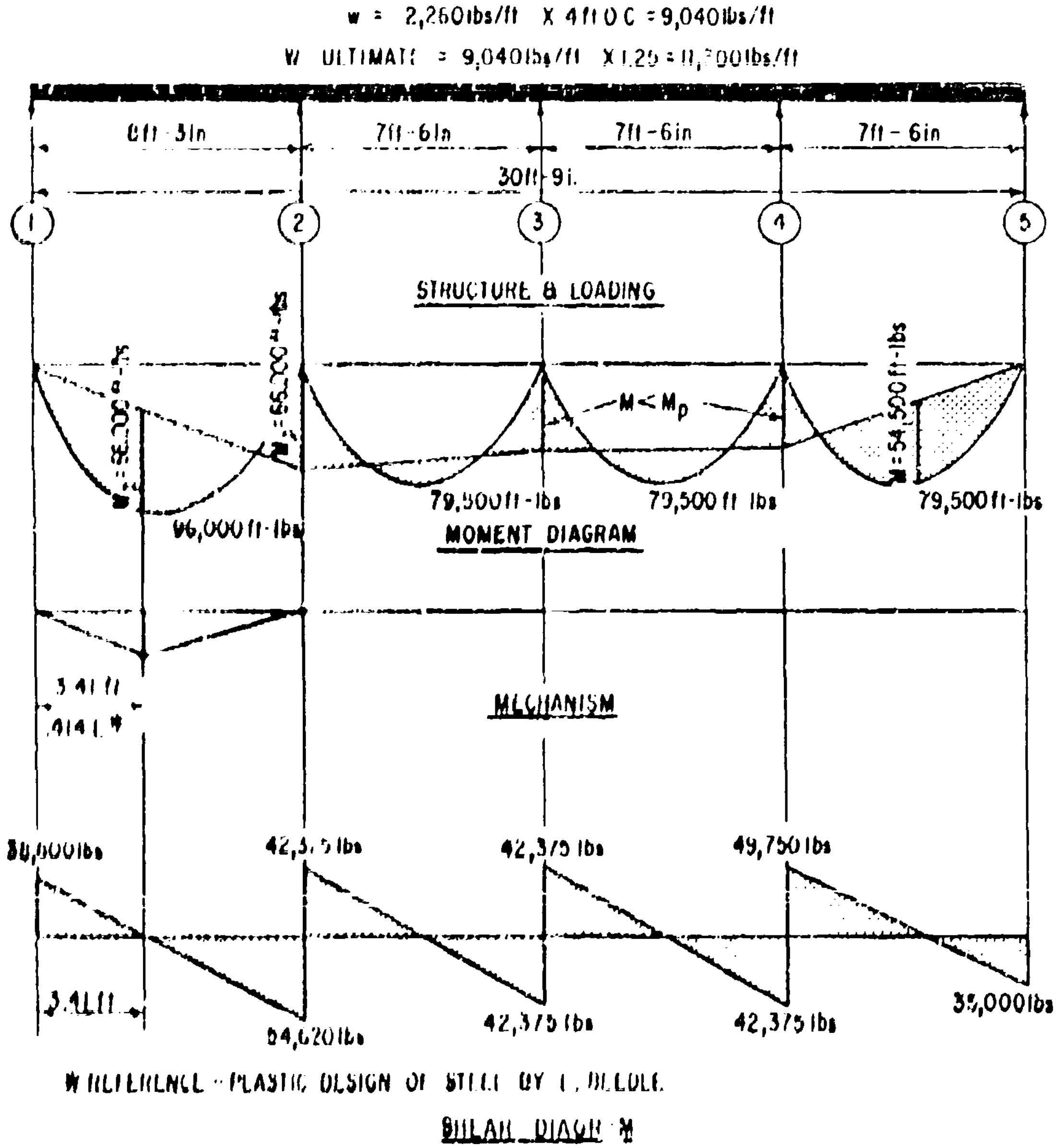

Figure 1. Structure and Loading, Determinate Moment Diagram, Mechanism and Shear Diagram

Double angle struts were used to simplify the end connections (one high-strength bolt in double shear). Although one-bolt connections are normally avoided, it was considered justified because of the temporary nature of the structure. All high-strength bolts were designed as friction type to eliminate cumulative tolerances so that rigid lateral support was attained for the inflexible concrete perimeter wall as shown on Figure 92.

A reinforced concrete perimeter wall 1-foot thick was more than adequate to support lateral loads. Reinforcing was kept to a minimum by using ultimate strength design. The walls spanned vertically from the test bed floor to a bond beam at the top, which was supported laterally at the north and south by the main steel beams, and at the east and west by the double angle struts as shown on Figure 89. The lateral reaction at the bottom of the wall was resisted by friction and No. 7 dowels spaced on 3-foot centers drilled into the rock as shown on Figure 92.

SECTION IV

DESIGN SERVICES PERFORMED

HANDEC I

Drawings and specifications were provided by AFWL for a test facility conforming to the following criteria and requirements:

1. The test bed consisted of a cavity 60 feet wide by 40 feet long with an interior height of 6 feet from the test bed floor to the bottom of support beams and subdecking.

2. The structure was required to support 30 feet of earth surcharge at 100 pounds per cubic foot, and was designed for a total load of 3000 pounds per square foot. Lateral loads were based on an active earth pressure of 40 pounds per cubic foot equivalent fluid pressure.

3. The test facility was designed with a 1-foot-thick reinforced concrete perimeter wall, steel beams, columns, bracing, roofdeck and subdeck. The corners of the perimeter walls were rounded to a 6-foot radius.

4. Surcharge and berm configuration were as shown on the drawings. (See Appendix III).

5. The cavity was filled with approximately 340,000 feet of 400 grain per foot detonating cord. The detonating cord (Government-furnished) was wrapped on wood racks at the specified weave angle of 53 degrees and installed in the cavity in nine layers. Drawings included rack and installation details. The perimeter wall and earth berm had eight 1-inch diameter plastic pipe penetrations for a planewave generator as shown on Figures 72 and 76.

6. Two surcharge dispersal cannisters were used. Charges were Government-furnished and Government-installed ammonium nitrate cannisters.

7. The instrumentation locations were incorporated into the final design drawings. All instrumentation was procured and installed by AFWL/WLCD and AFSWC technicians and the E. H. Wang Civil Engineering Research Facility.

8. A trenching plan and cable protective system was provided.

9. An area excavation plan showing existing grades and rock elevations on a 4 foot by 7 feet - 6 inches grid was provided.

10. An area excavation plan for the test structures and their dimensions within the test bed was provided.

11. Plans were provided for additional bays for the instrumentation trailer protective structure.

12. Preliminary and final specifications were prepared in normal construction specification format.

HANDEC II

1. The test bed consisted of a cavity 90 feet wide by 60 feet long with an interior height of 5 feet from the test bed floor to the bottom of support beams.

2. The overpressure support structure was required to support 20 feet of earth surcharge at 100 pounds per cubic foot, and was designed for a total load of 2100 pounds per square foot. Lateral loads were based on an active earth pressure of 40 pounds per cubic foot equivalent fluid pressure.

3. The test facility was designed with 1-foot-thick reinforced concrete perimeter wall, steel beams, columns, bracing, roofdeck and subdeck. The corners of the perimeter walls were rounded to a 6-foot radius.

4. Surcharge and berm configuration for the HEST and DIHEST were as shown on the drawings. (See Appendix IV).

5. The cavity was filled with approximately 380,000 feet of 400 grain per foot detonating cord. The detonating cord (Government-furnished) was wrapped on wood racks at a specified weave angle of 36 degrees and installed in the cavity in five layers. Drawings included rack and installation details. The perimeter wall and earth berm had twelve 1-inch diameter plastic pipe penetrations for the planewave generator.

6. Three surcharge dispersal cannisters were used. Charges were Government-furnished, Government-installed ammonium nitrate cannisters.

7. The instrumentation locations provided by AFWL were incorporated into the final design drawings. All instrumentation was procured and installed by technicians from AFWL, AFSWC and the E. H. Wang Civil Engineering Research Facility.

8. A trenching plan and cable protective system was provided for both surface and buried pipe.

9. A test bed plan showing existing natural grades and rock elevations on a 15 by 15 foot grid was provided.

10. An area excavation plan showing dimensions of the test structures within the test bed was provided.

11. Preliminary and final specifications were prepared in normal construction specification format.

12. A pre-fabricated metal storage building 40 feet by 100 feet with interior lighting was designed.

13. A secondary electrical distribution system was designed for electrical power to supply all instrumentation trailer and utility requirements.

14. Extension of electrical service provided by AFWL on HANDEC I was designed for five outlying areas: (1) construction yard, (2) location of test bed construction for both tests, (3) explosive storage area, (4) detonating cord wrapping area, (5) the pre-fabricated metal storage building.

15. Flood lighting was designed for the following locations in the number indicated:

a. Trailer Shelter - 4 each (permanent).

b. Explosive Storage Area - 4 each (permanent).

c. Detonating Cord Wrapping Area - 2 each (permanent).

d. Test Facility - 4 each (portable).

e. Pre-Fab Storage Building - 1 each (permanent).

Flood lights were furnished by the Government.

16. Lightning protective systems for the following areas were designed as shown on Figure 105.

a. HANDEC I Test Area.

b. HANDEC II Test Area.

c. Detonating Cord Rack Storage Area.

d. Explosive Storage Area.

SECTION V

CONSTRUCTION TASKS PERFORMED FOR HANDEC I AND II

The contractor provided all plant, labor, equipment, and materials (except those stipulated as Government-furnished) to perform the following construction tasks:

1. Grading and excavation as required for the test beds.

2. Furnishing all structural materials and the construction of the test facilities in accordance with the drawings shown in Appendices III and IV.

3. Placing the surcharge on, and building the berms around, the test facilities.

4. Furnishing and installing the plastic irrigation pipes through the wall and the berm for protection leads to the planewave generator.

5. Furnishing all materials and constructing the explosive racks, wrapping the detonating cord on the racks and installing the wrapped racks into the test facilities.

6. Furnishing all material and constructing an explosive rack support system.

7. Excavating 3-foot deep instrumentation cable trenches in the test bed as detailed on the drawings.

8. Locating the trenches and test structures in the test beds for the Government-furnished and operated drill rigs.

9. Furnishing all materials and constructing the AFWL instrumentation cable protection system as detailed on the design drawings.

10. Removing all rock material from trenches and test structures as shown on the design drawings except the unlined silo on HANDEC I.

11. Furnishing all material and constructing the research test model supports and the test structures in accordance with the design drawings and specifications.

12. Filling of all instrumentation cable trenches with a 15 to 18 inch sand cushion in the trench bottom and providing a 3000 psi concrete cap to the level of the test bed.

13. Constructing a 6 bay instrumentation trailer shelter and berm.

14. Constructing a 40 foot by 100 foot pre-fabricated storage building.

15. Furnishing all material and fabricating four sheet-metal targets.

16. Furnishing all material and constructing four lightning protective systems, one at both test facilities, one at the explosives area, and one at the rack storage area.

17. Constructing an explosive storage bunker in accordance with AFWL drawings.

18. Grading, compacting and constructing necessary drainage of local access roads to all storage, construction and work areas. The total length of all access roads was to be approximately 10,000 feet according to the statement of work.

19. Furnishing all necessary snow removal of all roads within the AFWL test site during the term of the contract.

20. Constructing the secondary distribution system for electrical power needed to supply all instrumentation trailer and utility requirements.

21. Hooking up and phasing of the instrumentation trailers with the isolation transformers.

22. Extending electrical power 208 and/or 120 vrms from the main power panel to five outlying areas.

23. Furnishing all material and labor to install lighting in the pre-fabricated building.

24. Installing all flood lights in accordance with the statement of work.

25. Renovating the test site after the completion of each test. Site renovation included the following:

a. Removal of the surcharge and debris from the entire test bed.

b. Removal of 125 linear feet of concrete cap from the cable protective trenches on the HANDEC II test bed.

26. Furnishing all labor and equipment for removal of all debris from both test sites.

27. Removing all test closures from HANDEC I and HANDEC II for AFWL inspection.

28. Furnishing and installing a four-strand barbed wire fence around both test beds after the test event.

29. Providing all necessary office facilities at the test site for contractor personnel in mobile vans.

30. Providing chemical toilets and drinking water for Air Force and construction personnel.

SECTION VI

CONSTRUCTION METHODS

The following is a listing and description of some of the unique construction procedures employed by the contractor to expedite construction and maintain the tight schedule. Throughout the entire project, time was economized and in some instances, production line methods were devised to achieve uniformity in construction and to minimize human error.

1. DETONATING CORD CUTTING AND SEALING

   Detonating cords were cut three at a time with a paper shear and then the cut ends were dipped into hot wax to seal them. This eliminated placing caps on or taping the ends of cord.

2. DETONATING CORD RACK FABRICATION

   All detonating cord rack members were cut to length and spacing blocks were stapled thereon in the contractor's shop in Cedar City. This enabled work to be performed inside during inclement winter weather conditions. Racks were then delivered to the job site for assembly, wrapping and final installation into the test bed.

3. DETONATING CORD RACK ASSEMBLY AND INSTALLATION

   After individual racks were wrapped with detonating cord, they were placed on wooden support racks to make up assemblies of the required number of layers. Once this operation was complete, all vertical ties were made between racks and the planewave generator distribution panels were connected, leaving only the horizontal ties to be made inside the test bed. Rack assemblies were then transported to the test facility with a forklift and lowered into

position with a crane. However, with this method, steel beams cannot be placed until detonating cord is placed in the test cavity.

4. PLACEMENT OF SUBDECK FILL

Subdeck fill was placed with a crane and bucket. This was possible since the plan dimensions of both the HANDEC I and HANDEC II test beds were relatively small.

5. ROOFDECK WELDING

All of the roofdeck was welded to the support beams by the "MIG Inert Gas Welding" process. This is a machine welding process whereby puddle welding is automatically achieved with a welding "gun." A preset timer insures uniform welds. The "burn-thru" method was employed, which allows welding in any location because tests conducted on the ROCKTEST I project demonstrated that pre-punched holes are unnecessary. This process has proved satisfactory because both fabrication costs and welding time were minimized. Sections cut through test welds showed complete penetration using this technique on the ROCKTEST I project.

6. TRENCH EXCAVATION

Numerous tests were conducted to determine the best method for blasting instrumentation trenches. After experimentation at the Cedar City test site, the contractor found that 400 grain detonating cord spaced in 2 3/4 inch holes on 1 foot centers each side of trenches produced the best method for trench excavation. (Corps of Engineers drilled the centerline of these trenches with 6-inch relief holes, side by side.) See Figure 2.

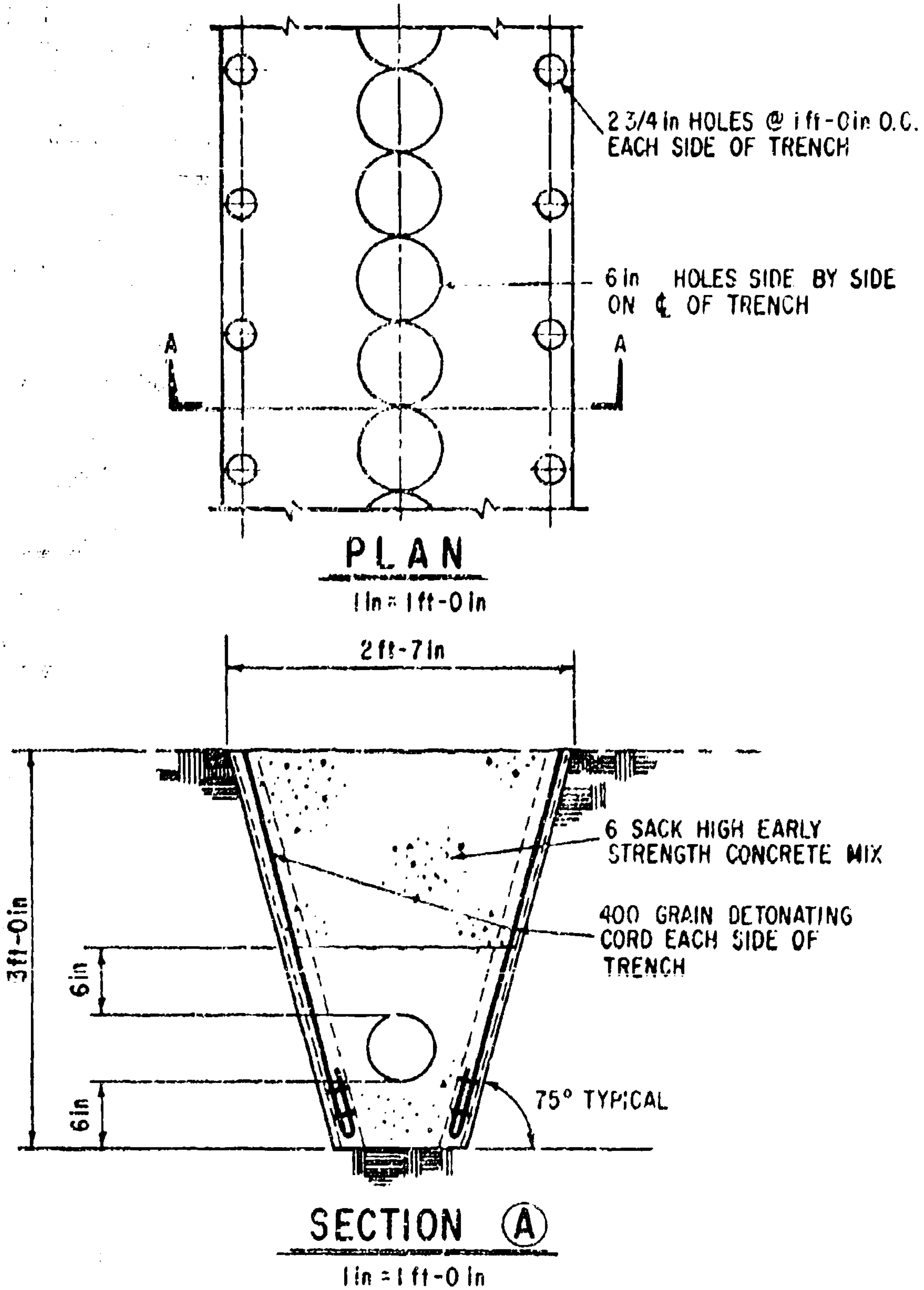

Figure 2. Typical Trench Blasting Method for HANDEC II

7. BACKPACKED SILO

Although only one steel liner was shown on the drawings, the contractor provided a steel shell on both sides of the reinforced concrete wall for the lined backpacked silo as shown on Figure 51. Reinforcing steel was placed on the inner liner and then the outside shell was placed and the concrete poured. The entire silo was then lifted into the rock cavity by use of a crane and backpacking material was applied between rock and outer steel shell. CERF personnel applied a low density foam concrete backpacking material as shown on Figures 55 and 56, between the outer steel liner and the rock.

SECTION VII

CONSTRUCTION PROBLEMS

Following is a summary listing of problems encountered during construction and a description of the solutions that were applied.

1. The cable protection trenches had to be left open until nearly the end of construction period because of instrumentation. This delay caused the construction contractor to hang steel columns to the beams supported by the walls in order to locate anchor bolt positions so that holes for base plates could be located and drilled. Beams then had to be removed in order to place detonating cord rack assemblies after fabrication. Detonating cord racks were then placed and subsequently the structural steel was reset.

2. The HANDEC II lined and lined-backpacked silos were line drilled around their perimeter with 6 inch holes. The initial drilling for the lined silo provided too small a diameter at the bottom of the silo because the Government-provided drill holes (drilled by COE) deviated from true vertical with depth. (See Figures 45 and 46.) This silo had to be enlarged by chipping with pavement breakers and drilling and shooting with 400 grain detonating cord. This problem can be avoided by drilling with a core barrel the same diameter as the silo (Calyx Method).

3. Due to safety requirements, the detonating cord racks for HANDEC II had to be moved and relocated because of the proximity of the HANDEC I test to the rack storage area.

4. Extreme difficulty was experienced on HANDEC I in fitting the detonating cord racks and rack supports between columns and into the cavity. The explosive density necessary to obtain the pressures desired from the test, coupled with sympathetic detonation minimum separation requirements, made the HANDEC I design approach the limit for detonating cord density attainable in a HEST facility. If higher pressures and other simulation effects of nuclear weapons are desired in the future, alternate methods to replace atmospheric detonation of detonating cord will have to be developed to meet these requirements.

5. Problems developed on the HANDEC II structures which were fabricated for the contractor by American Bridge. Silo closure bearing rings were not level and several model structures had the top bearing ring spliced and welded in violation of the design drawings. AFWL HANDEC II drawings, however, did not specify the bearing surface tolerances which were desired. (See Figures 47 and 48.) This had not been specified before on the ROCKTEST I test and satisfactory structures were obtained. The contractor, through AFWL, returned these structures and models to American Bridge for correction. This problem delayed instrumentation installation and the contractor while American Bridge made the necessary corrections to these structures.

6. Detonating cord rack supports for HANDEC I (see Figure 75) were redesigned by the contractor for better structural support. Dowels and 2 by 2 inch lumber were eliminated, thereby requiring fewer piece parts and less labor during assembly. (See Figure 3.)

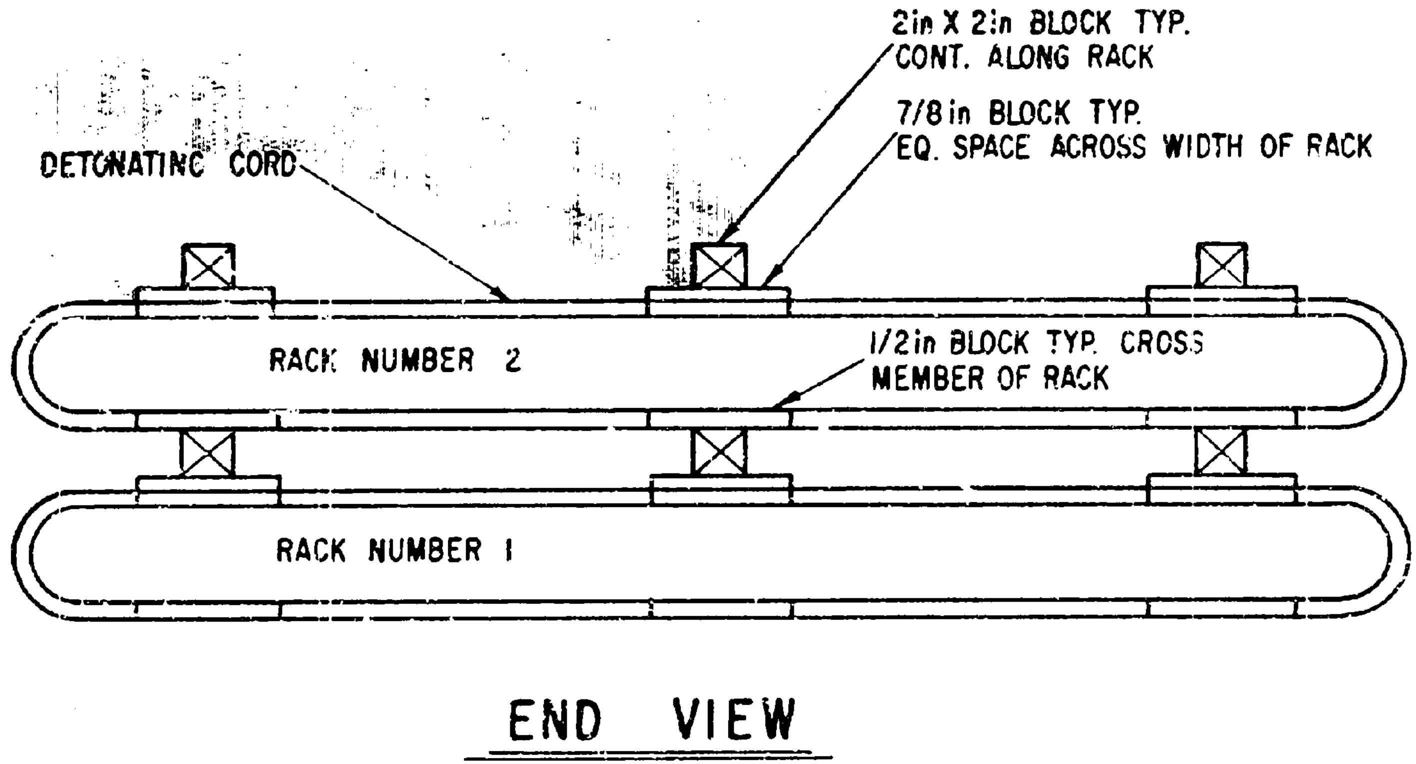

Figure 3. Typical Rack Support for HANDEC I

7. Trouble was experienced on site with the three wire number 4-0 aluminum direct burial insulation cable providing 480 volt electrical service to the outlying construction areas. These cables were installed under the HANDEC I portion of the electrical work. Power was lost directly to ground and the contractor burned out numerous small power tools due to lack of sufficient power.

8. Although not a construction problem as such, on test event day during removal of vehicles and construction equipment in preparation for the HANDEC II test event, a COE rig drove into the primary power supply downing one wire and knocking out power to instrumentation trailers and site at T - 2 1/2 hours. This caused a four hour delay in the test and the countdown had to be restarted. This delayed the contractor from returning construction equipment and crews until the next day.

9. The contractor was delayed by the Government for the following reasons:

a. AFWL was conducting a series of sixteen experiments named "Merry-Go-Round II" on site to determine the following:

(1) Exact type of explosive to be used for the DIHEST portion of HANDEC I and HANDEC II tests.

(2) Dynamic shock propagation characteristics of the in situ rock.

(3) Effects of various explosive-to-rock coupling techniques on free field stress wave forms generated in this type rock.

(4) Instrumentation function in this rock under shock loading.

These sixteen experiments, conducted in thirty days, caused the contractor delays because construction equipment and personnel had to be moved for safety requirements during these tests.

b. Once an explosive had been chosen, AFWL conducted the DATEX I Experiment to give further information needed for the HANDEC I test.

c. After completion of the HANDEC I test, AFWL conducted DATEX II to provide data necessary for the HANDEC II DIHEST requirements.

d. Instrumentation procurement and installation delayed the contractor from meeting the schedule originally required by the statement of work. The contractor had to hold his construction personnel on a standby basis to complete the project.

10. During construction of the HANDEC II HEST facility structure, a fabrication error occurred. Design drawings specified beams to be spliced at 30 feet - 0 inch o.c. Structural steel beams were delivered to the test site in 46 feet - 0 inch lengths. A structural design check by AFWL personnel revealed that greater structural continuity would be obtained with the longer beams and only one splice point at the center line of the structure. Web doubler plates were welded to the beam webs at the first interior support each side of the splice to take the critical shear loads. This avoided returning the structural steel to the fabricator for correction and prevented loss of construction time.

SECTION VIII

CONCLUSIONS AND RECOMMENDATIONS

Based on the problems encountered and experience gained on this project, the following conclusions and recommendations are made for application to similar projects that may be undertaken in the future.

1. Structural Concept Study

If HEST and DIHEST testing is to be continued in the future over increasing larger areas, it is recommended that structural design concepts and trade-off studies be performed to determine the optimum and most economical structural framing system for these facilities compatible with new explosive techniques which may be developed for future HEST and DIHEST projects. For example, an alternate framing method would be to pour high-early strength concrete directly over the subdecking now used, thereby eliminating the steel strut angles between beams and their high strength bolted connections plus the cost of the structural steel decking. Additional savings from use of this technique would be realized from labor saved by steel erection, the elimination of earth fill between both decks and the installation and welding of the structural deck now used to brace the steel beams and support the surcharge. These savings coupled with the fact that competent, efficient iron workers are scarce in remote test site areas should prove to be a significant cost saving to the government.

Unlike design of structures to resist usual loads, wherein most design stresses remain well under the yield point of materials, economy in design of HEST-DIHEST facilities dictates that they sustain as much deformation as can be allowed within their ability to perform the function of a "temporary structure" in accordance with Air Force Design Manual 88-3, utilizing plastic or ultimate strength design methods.

Other building materials and construction methods should be studied to obtain an ideal structural module, in an attempt to eliminate some of the many columns and beams now required for these structures. Composite design and precast, prestressed and reinforced concrete construction should be investigated. Construction cost estimates should be included with this study. Once such a study has been completed and several alternate concepts have been selected, actual field loading of these facilities to failure should be conducted to further correlate design with failure modes. This will enable the structural designer to verify ultimate load, determine the mode of failure and provide a suitable safety factor for much larger future facilities.

2. Test Site Survey

The entire test site should be surveyed by a competent registered civil engineer or licensed land surveyor prior to any work on the test site. Depending on site location and local terrain, clearing the test site of trees and brush might be the initial consideration. Drawings at a suitable scale should be provided to show the following:

a. Limits of government property or test site.

b. Existing natural contours at 5-foot intervals.

c. Location of test bed giving rock and soil elevations at a specified grid.

d. Location of existing bench marks.

e. Provision and location of additional markers which cannot be destroyed by construction equipment or the test event.

Once this survey is completed the entire test site should be planned for:

a. Necessary roads

b. Contractor construction yard

c. Soil borrow location

d. Water storage

e. Temporary structures

f. Parking area

g. Trailer area

h. Material storage area

i. Lighting and power poles

j. Security

k. Explosive storage area

l. Explosive buildings

m. Detonating cord storage area

n. Instrumentation protective trailer structure

o. Metal bunkers for instrumentation

p. Concrete batch plant

q. Corps of Engineers construction yard if applicable

r. Camera towers

s. Lightning protection

3. <u>Portable Materials Testing Laboratory</u>

An agency of the Air Force should [illegible] modern portable materials testing laboratory and train or obtain qualified personnel to operate such a facility for future governmental projects of this nature. Such a facility

would enable the government to verify quickly the compliance with specification of building materials as they arrive on a test site. Test data delays could be avoided by early action should a product not conform to the requirements of the design specifications. This portable laboratory should contain a complete set of Military Standard specifications and ASTM specifications. The laboratory should be capable of testing concrete, structural steel, reinforcing steel, steel decking, bolts, high strength bolts, inserts, etc. The Air Force testing agency should then provide the contractor and necessary Air Force personnel with a written report within twenty-four hours containing the results of the tests performed, and their compliance with job specifications.

4. Camera Tower

One camera tower and the high speed cameras installed thereon, located 460 feet from the HANDEC II test bed, was severely damaged and brought down by the HANDEC II test event flying debris and ground shock. The high speed cameras (1500 frames per second) were located at this range in order to photograph the one-inch line markers on the targets placed atop the surcharge during the test. See Figure 93. Damage to the cameras and their protective cases was estimated at \$7,000.00. The tower was a rented type scaffolding, guyed by wire, at several locations. Although the cameras were damaged, the necessary photography was obtained from the test.

The AFWL should investigate the use of wider markers on these targets in order to locate camera towers at a greater distance on future tests to avoid additional costs to the government, provided all technical data requirements can still be obtained.

5. Drilling Services

Several test facilities have been constructed in rock sites and trouble has been experienced on each project with government drill crews being unable to drill within dimensions and tolerances required by plans and specifications. Therefore, it is recommended to avoid recurrence of this same problem on future projects, that a study and test drilling and excavation program be conducted by a consulting engineer, contractor, or the government to compare drilling methods, drilling tolerances, and excavation techniques, time and costs with those now being used.

6. Electrical Power

Direct burial cable to the HANDEC I test bed and outlying areas as shown on Figures 65 and 86 gave unsatisfactory power at these locations. The combination of wire size used for the distances required with the direct burial of the wire gave excessive electrical loss directly to ground. It is therefore recommended for future tests a licensed professional electrical engineer provide all electrical design and that all electrical wire be placed in either Rigid Steel Conduit meeting Federal Specification WW-C-581 or Plastic (PUC) Conduit Federal Specification W-C-1094.

7. Shop Inspection

The responsible Air Force organization or design agency should provide shop inspection by qualified inspection personnel during the fabrication phase of the structural steel and steel decking to assure conformance with design drawings, specifications and approved shop drawings. This will also guarantee that steel suppliers meet their delivery schedules.

8. Instrumentation Cable Protective System

Three types of instrumentation cable protective systems were tested on the HANDEC I and HANDEC II tests. They were as follows:

a. Schedule 80 steel pipe, placed in a rock trench, sand enclosed and concrete capped as shown on typical trenching section Figure 96.

b. Schedule 80 steel pipe, surface anchored to the rock with steel straps at 2 feet - 0 inch o.c. as shown by detail 1 in Figure 96.

c. Schedule 80 steel pipe, split half with steel flanges welded to the pipe at 2-foot intervals for bolting the two pieces of pipe with 3/8 inch bolts after the instrumentation cable had been installed. This system avoids threading the steel pipe over the instrumentation wire bundles, as required by a. and b. above.

The AFWL technical report on test results should evaluate instrumentation results using these three protective systems to determine which system should be used for future HEST-DIHEST testing to provide the greatest cost saving to the Government.

Future HEST-DIHEST tests should design and test other methods such as:

a. Shallow trench with reinforced concrete cover slab.

b. Plain sand burial.

c. Shallow trench, concrete encased and reinforced.

d. Cable encased in low density foam concrete.

e. Various types of cable with some of the above-mentioned design concepts.

9. As-Built Drawings

Minor instrumentation changes were made just prior to loading the test pits with detonating cord. Since these changes are often forgotten weeks or months after test event, it is recommended that future statements of work for similar tests provide for making as-built drawings to reflect late instrumentation, research structure or structural changes to provide the Government with a permanent construction record.

10. Schedule

The HANDEC I test event was originally scheduled to take place 100 days after contract award and the HANDEC II test was to be conducted 150 days after contract award. Delays were encountered on both tests due to no fault of the construction contractor. Because of technical requirements, an entire series of twenty tests (including HANDEC I and II) had to be conducted in a very small area (less than 1000 feet diameter). All of the above testing had an impact on the original statement of work. Other delays encountered were in instrumentation procurement (since these are long lead time items) and installation of instrumentation in structures and research models. Still another factor which had some impact on the schedule was that during construction of these projects, the contractor was contracted to clean the ROCKTEST II test bed for visual inspection and photographic coverage by the Air Force from work performed by a previous AFWL contractor. AFWL then contracted with the contractor to lower the ROCKTEST II test bed approximately seven feet in an attempt to obtain a more level test bed for the surcharge support structure. All of the above items delayed the construction contractor. HANDEC I was completed in 156 days after contract award and HANDEC II required 212 days to complete. Therefore, HANDEC I required

an additional 56 days, and HANDEC II required an additional 62 days. Considering the number of tests performed by AFWL in such a short period of time, it appears that the delays encountered were justifiable since much of the construction was performed in the winter months during inclement weather.

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APPENDIX I

RESUME OF BI-WEEKLY PROGRESS LETTERS

During the contractual period of performance, bi-weekly progress letters were submitted to the AFWL Project Office and AFSWC Procurement Division by the contractor. These reports provided a summary of the project status with respect to schedule, problem areas, trips, meetings, conferences and program funding.

The contents of each of the bi-weekly letters are summarized below to provide a chronological account of the major events occurring during the performance of this project. If more detailed information is desired, reference should be made to the specific progress letter for the period concerned.

1. FIRST BI-WEEKLY PROGRESS LETTER (January 15, 1969 to January 24, 1969)

   a. Contractor Design Services for HANDEC II

      Preliminary design, calculations, drawings and specifications were in progress for HANDEC II in accordance with the statement of work.

   b. Contractor Construction Services for HANDEC I and II

      The contractor commenced loading construction materials and equipment from their Albuquerque construction yard in preparation for movement to the AFWL test site, Cedar City, Utah. The first load of equipment arrived on site January 15, 1969. Orders were placed for structural steel for AFWL models on HANDEC I and for structural steel, structural steel decking, subdecking and rebar for the HANDEC I and HANDEC II HEST facilities. The instrumentation trailer protective structure structural steel used on the ROCKTEST I test was trucked to the Cedar City test site. Trailer structure footings and piers

were formed and grading and drilling at the HANDEC I site was commenced. Detonating cord rack supports were redesigned for better structural support.

2. SECOND BI-WEEKLY PROGRESS LETTER (January 27, 1969 to February 7, 1969)

a. Contractor Design Services for HANDEC II

Work continued on design drawings and specifications for HANDEC II structure.

b. Contractor Construction Services for HANDEC I and II

Reinforcing for trailer shelter structure footings and piers was placed and tied. Cold weather and snow hampered construction activities requiring removal of steel from the footings and snow from excavations. Concrete (24 yards) was heated and poured for trailer structures. Drilling, blasting and rock removal at the HANDEC I test bed continued. The test bed was then cleaned with compressed air. Inspection and further direction was requested by the contractor from AFWL before proceeding further. Drilling and blasting for power poles commenced. Another safety meeting was held on site February 6, 1969.

3. THIRD BI-WEEKLY PROGRESS LETTER (February 8, 1969 to February 21, 1969)

a. Contractor Design Services for HANDEC II

Progress continued on design drawings and specification for the HANDEC II facility. The design drawing package consisted of eleven structural drawings and six electrical drawings.

b. Contractor Construction Services for HANDEC I and II

Work continued on the trailer structure foundations and erection of structural steel commenced. Trenches were

opened and electric cables placed and backfilled. Work continued maintaining roads and on additional access roads. Construction was started on the explosive storage berms. Work on the lightning protection system and lighting in this area commenced. The Corps of Engineers commenced perimeter drilling of the lined and unlined silos for HANDEC I. Drilling of explosive shot holes for the HANDEC II test bed began. Chemical toilets for site were completed. The distance required to bring water to the site was measured.

4. FOURTH BI-WEEKLY PROGRESS LETTER (February 22, 1969 to March 7, 1969)

a. Contractor Design Services for HANDEC II

Mr. Howard Taylor, Consulting Civil Engineer, delivered the preliminary submittal of design plans and specifications to Lt. Vergnolle, AFWL, on site March 1, 1969.

b. Contractor Construction Services for HANDEC I and II

Construction was hampered due to weather conditions and heavy snow, but the trailer shelter structure was completed and construction was started on the detonating cord racks in the contractor's shop located in Cedar City. Electric work was completed except for lighting of the metal storage building. Additional drilling and blasting was required due to the addition of free field instrumentation holes for both HANDEC I and HANDEC II. Structures 3, 4, 5 and 6 and free field instrumentation holes for Corps of Engineers drilling on HANDEC I were surveyed and excavation of the HANDEC II test bed was completed. A crane was operated for AFWL personnel photographic coverage. Berms were started for the trailer shelter structure protection.

5. FIFTH BI-WEEKLY PROGRESS LETTER (March 8, 1969 to March 21, 1969)

a. Contractor Design Services for HANDEC II

Work continued on the HANDEC II facility design. Corrections on preliminary plans and specifications were expected soon from AFWL, so that the final design submittal could be made.

b. Contractor Construction Services for HANDEC I and II

Detonating cord rack and rack supports were completed for HANDEC I and construction of racks for HANDEC II were started. Foundations were formed, steel placed, concrete poured and structural steel erected to complete the 40 by 100 foot metal storage building. Work was started on the trailer shelter earth berm. Water pipe was received and installed to provide site with construction water. Shop fabrication was started on the instrumentation cable protective system. Guard shacks were built and delivered to the site and a culvert under the main access road to site was placed. A survey was made for instrumentation trench locations on HANDEC I and the contractor was requested to survey and clean the ROCKTEST II test bed. Corps of Engineers drilled instrumentation holes in lined and unlined silos on HANDEC I for instrumentation, started center-line drilling for instrumentation trenches, and began drilling silos for the HANDEC II structure.

6. SIXTH BI-WEEKLY PROGRESS LETTER (March 22, 1969 to April 4, 1969)

a. Contractor Design Services for HANDEC II

Work on final design, calculations, drawings and specifications continued. Final design submittal target date was set for April 14, 1969.

b. Contractor Construction Services for HANDEC I and II

Work continued on the cleaning of the ROCKTEST II test bed. Reinforcing on silos and models was placed, structures were set in place for HANDEC I and the specified concrete for structures 01 through 06 was poured. The metal storage building was completed for occupancy by the Air Force. Work continued on drilling and blasting for instrumentation trenches on HANDEC I. Detonating cord racks were delivered to the site while fabrication of lumber for the HANDEC II test continued in the contractor's shop. Wrapping the 400 grains per foot detonating cord on fabricated racks was started, transformers were set to complete the first phase of the electrical work on site and the explosive storage berms were completed. The revetment building materials for transformer protection and cable junctions was received on site. A contractor's crane was used for photography of the ROCKTEST II test bed for AFWL. The Corps of Engineers started drilling of perimeter holes for the HANDEC II structures, cable trenches and the free field holes.

7. SEVENTH BI-WEEKLY PROGRESS LETTER (April 5, 1969 to April 18, 1969)

a. Contractor Design Services for HANDEC II

Final design plans, specifications and calculations were submitted to AFWL on April 14, 1969. Plans and specifications were approved by Capt. Philip Madden on this date. Final chronoflex drawings and specifications were transmitted to AFWL on April 25, 1969.

b. Contractor Construction Services for HANDEC I and II

Wrapping of detonating cord racks for HANDEC 1 was completed. Rebar and dowels were placed and concrete walls

were poured for the HANDEC I structure. Anchor bolts for columns were drilled, set and grouted, columns and beams were placed and base plates were dry-packed. The instrumentation trench concrete cap was poured to specified strength. HANDEC II work continued on chipping and cleaning rock from instrumentation trenches. Placing and tying wall steel was begun on HANDEC II, while detonating cord rack fabrication continued. Lighting for metal storage building was completed and construction of revetments and earth overburden was started at eleven locations. The ROCKTEST II activity consisted of air blowing the rock surface of the pit for photography by the Air Force Weapons Laboratory.

8. EIGHTH BI-WEEKLY PROGRESS LETTER (April 21, 1969 to May 2, 1969)

a. Contractor Construction Services for HANDEC I and II

Beams for HANDEC I were removed in order to allow CERF to place instrumentation. Structures were cleaned of dirt and water caused by high winds and rain. Fabrication and installation of the hardened instrumentation cable protective system was accomplished.

Work on HANDEC II consisted of drilling explosive holes, loading and shooting trenches and structures. Rock removal continued after each shot to clean trenches and silos. Detonating cord rack wrapping commenced. Rebar was tied directly on steel shells. Structural steel arrived for HANDEC II. Revetments were placed and constructed for the DATEX I test firing system. AFWL moved four trailers into the trailer shelter protective structure.

9. NINTH BI-WEEKLY PROGRESS LETTER (May 5, 1969 to May 16, 1969)

a. Contractor Construction Services for HANDEC I and II

Contractor activities on HANDEC I consisted of placing closures over silos with crane, completing the instrumentation cable protective system and placing all detonating cord racks in test bed by use of crane. All horizontal ties for detonating cord and planewave generator details were completed, beams, subdecking and decking completed and deck was welded in accordance with design drawings. Berm and surcharge placement was commenced and revetments outside the berm area for the DIHEST firing system were placed.

Activities for HANDEC II included drilling, shooting and removing rock from silos which were drilled out of plumb by the Corps of Engineers, wrapping racks and assembling them on support racks. Rack construction was completed and racks were covered with tarps on May 16, 1969.

10. TENTH BI-WEEKLY PROGRESS LETTER (May 17, 1969 to May 30, 1969)

a. Contractor Construction Services for HANDEC I and II

Construction activities for HANDEC I consisted of continuation of berm and surcharge placement, erection of targets on surcharge, drilling of two surcharge dispersal holes, locating and erecting two camera towers, blading observation area for test event, and removing all equipment from site for the HANDEC I test conducted on Thursday, May 29, 1969.

Construction continued on HANDEC II as follows: Planewave distribution panels were assembled, instrumentation cable protective system design was revised by AFWL, removal of rock from all structures continued, borrow area was cleared,

rebar and rebar mats were placed for structures, steel liners were welded and instrumentation holes located.

11. ELEVENTH BI-WEEKLY PROGRESS LETTER (June 2, 1969 to June 13, 1969)

a. Contractor Construction Services for HANDEC I and II

Construction tasks were the surcharge and berm removal on HANDEC I, removal of debris and clean up of test bed on HANDEC II caused by the HANDEC I shot, and removal of all closures for AFWL inspection.

HANDEC II activities continued with placing dowels, wall forms and reinforcing steel for the exterior concrete walls. Rebar placement on structures continued. Structures were placed, leveled, and concrete poured for structures 13, 14, 15, 16, 17, 18 and 19. The instrumentation cable protective system was fabricated. A revised trenching plan was received from AFWL and five free field holes were drilled to greater depth by the Corps of Engineers.

12. TWELFTH BI-WEEKLY PROGRESS LETTER (June 16, 1969 to June 27, 1969)

a. Contractor Construction Services for HANDEC I and II

HANDEC II walls were formed, reinforced, poured and forms removed. Anchor bolts were drilled, set and grouted for overpressure structure columns. AFWL silos, closures and trenches were poured. PDQ III test was conducted June 23, 1969 and all equipment removed from site. Beams and columns were placed for the surcharge support and CERF placed instrumentation.

13. THIRTEENTH BI-WEEKLY PROGRESS LETTER (June 30, 1969 to July 11, 1969)

a. Contractor Construction Services for HANDEC I and II

Work continued to chip rock to open instrumentation trenches. Column setting and dry-packing continued as did fabrication and installation of instrumentation cable protective system. Contractor's crane and personnel were used to help AFWL and CERF place instrumentation cable in protective pipe. Closures from the HANDEC I test were moved to the DATEX II site.

14. FOURTEENTH BI-WEEKLY PROGRESS LETTER (July 12, 1969 to July 25, 1969)

a. Contractor Construction Services for HANDEC I and II

Activities consisted of continuing work on the instrumentation cable protective system, backfilling the trenches with sand and pouring the top concrete cap. Construction of the berm was started for that portion that fell within the ROCKTEST II test bed. Detonating cord racks were placed into the pit with a crane and horizontal ties were made. Lightning protection poles were placed and placement of beams and subdeck commenced.

15. FIFTEENTH BI-WEEKLY PROGRESS LETTER (July 26, 1969 to August 8, 1969)

a. Contractor Construction Services for HANDEC I and II

Placement of subdeck and steel beams for HANDEC II was completed. Steel decking was welded to beams and seams were crimped in accordance with design drawings. Backfill was placed around walls, surcharge and earth berms were placed and the DIHEST berm was started after AFWL had completed placing the DIHEST explosives.

16. SIXTEENTH BI-WEEKLY PROGRESS LETTER (August 9, 1969 to August 22, 1969)

a. Contractor Construction Services for HANDEC I and II

DIHEST berm construction for HANDEC II was completed and all equipment was removed from site August 14 in preparation for the HANDEC II test event. After the test event, all equipment was returned to the test site and work commenced on removal of HANDEC II surcharge, earth berms, and earth and rock which entered the ROCKTEST II test bed.

17. SEVENTEENTH AND EIGHTEENTH BI-WEEKLY PROGRESS LETTER (August 23, 1969 to September 10, 1969)

a. Contractor Construction Services for HANDEC I and II

All beams, deck, subdeck, and earth surcharge were removed to expose the HANDEC II test bed for visual observation of test structure responses and the recovery of self-recording instrumentation. All research models and silo closures were removed for inspection by AFWL and the concrete cap from 125 linear feet of cable trench was removed for inspection and gage recovery by AFWL.

APPENDIX II

CONSTRUCTION PHOTOGRAPHS

This appendix contains Figures 4 through 62 which is a collection of construction photographs selected to present a pictorial record of the significant and/or unique construction events and to illustrate the progress of the job.

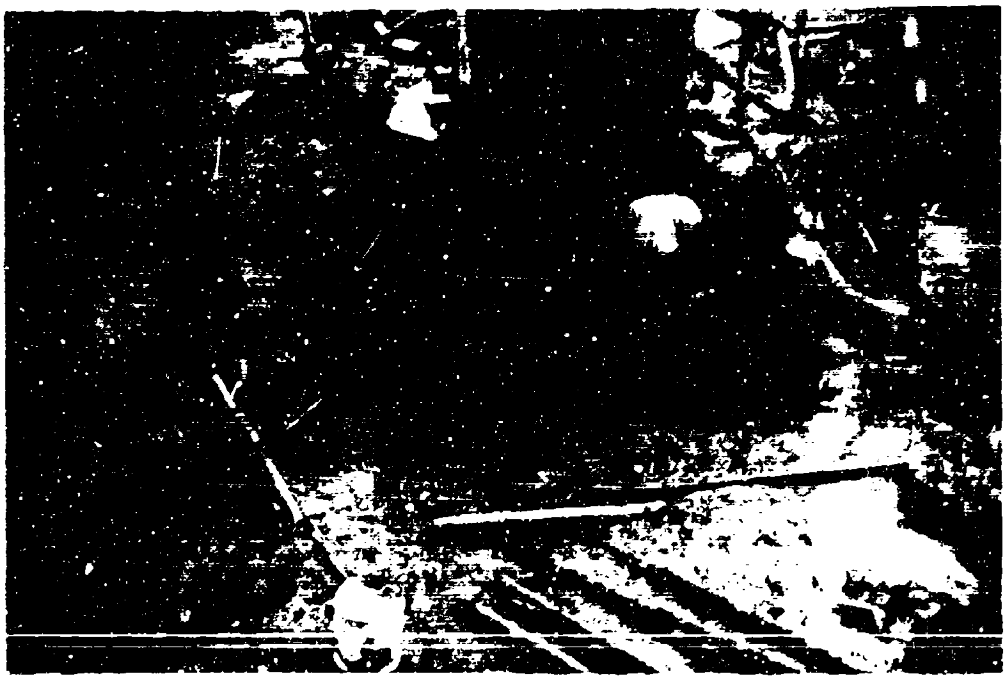


Figure 4. Government Drill Crews Line Drilling the Perimeter of the AFWL Lined Silo for HANDEC I, February 1969.

Figure 5. HANDEC I Rock Drilling During February 1969.

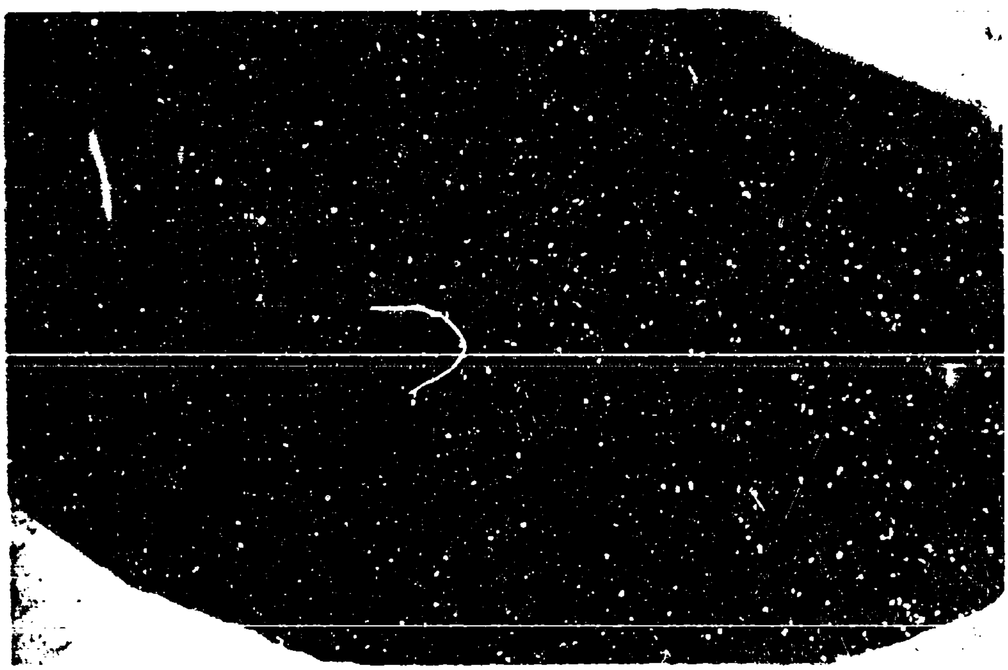


Figure 6. AFWL Unlined Silo, HANDEC I.

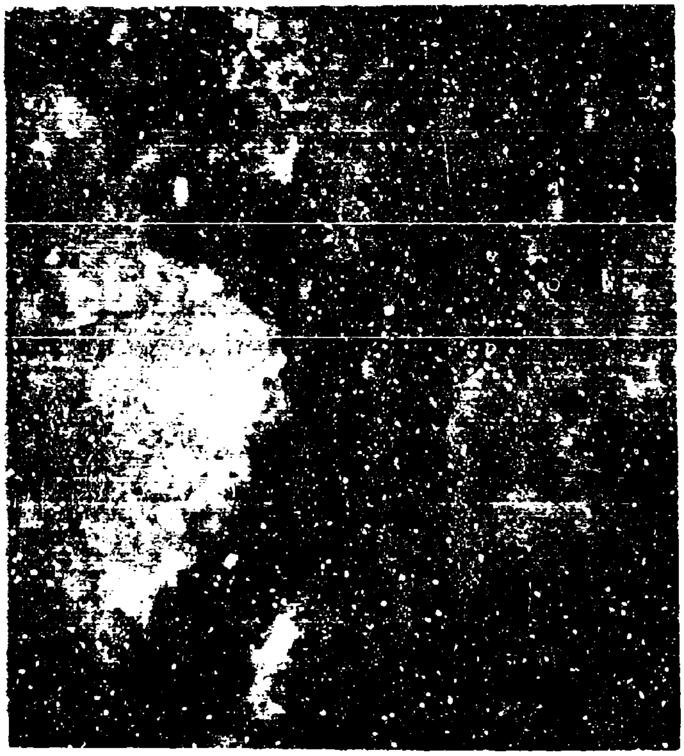


Figure 7. Perimeter Holes Drilled for AFWL Lined Silo, HANDEC I.

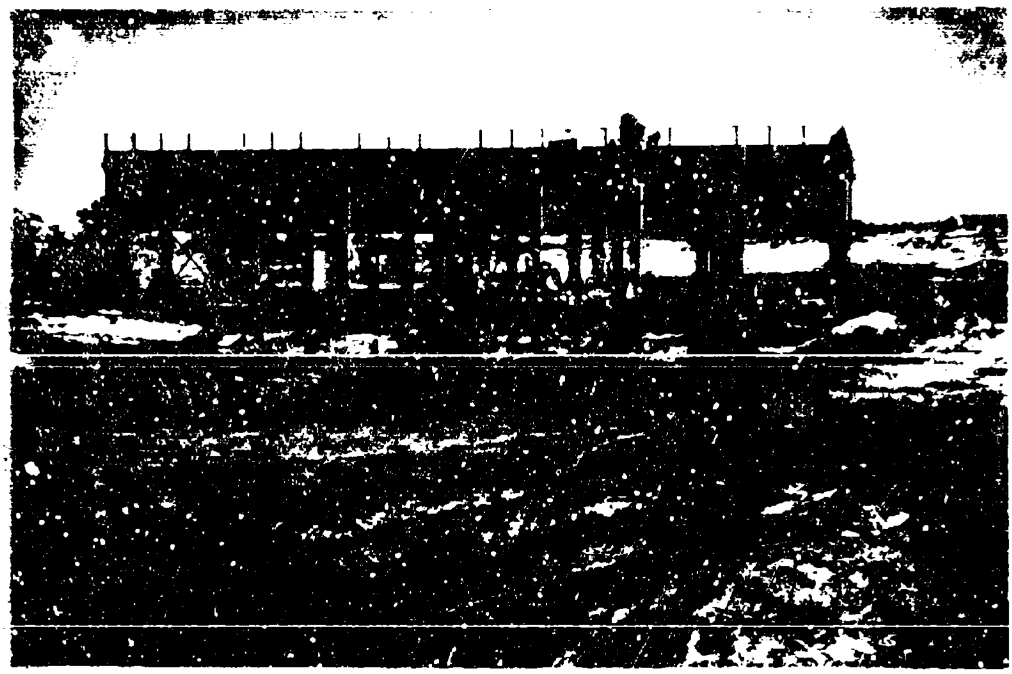


Figure 8. Instrumentation Trailer Protective Structure, February 1969.

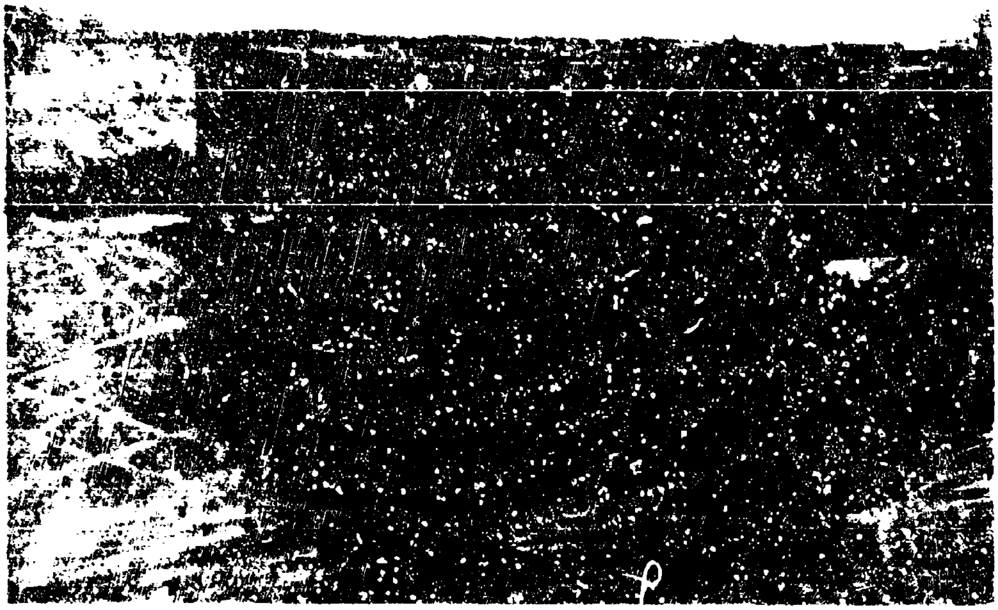


Figure 9. Trailer Protective Structure with Earth Fill on Top and Earth Berms in Background.

Figure 10. Erection of 40-Foot by 100-Foot Pre-Fabricated Metal Storage Building.

Figure 11. Completed Metal Storage Building.

Figure 12. AFWL Research Models and Closure Steel Shells for HANDEC I.

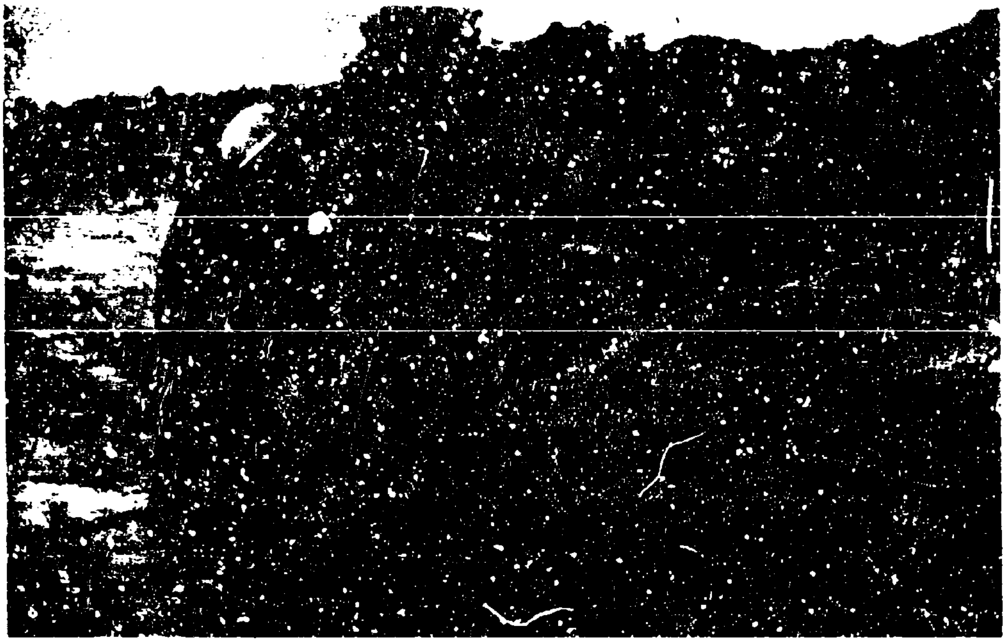


Figure 13. Cutting Liner Plate for Instrumentation Penetration, HANDEC I.

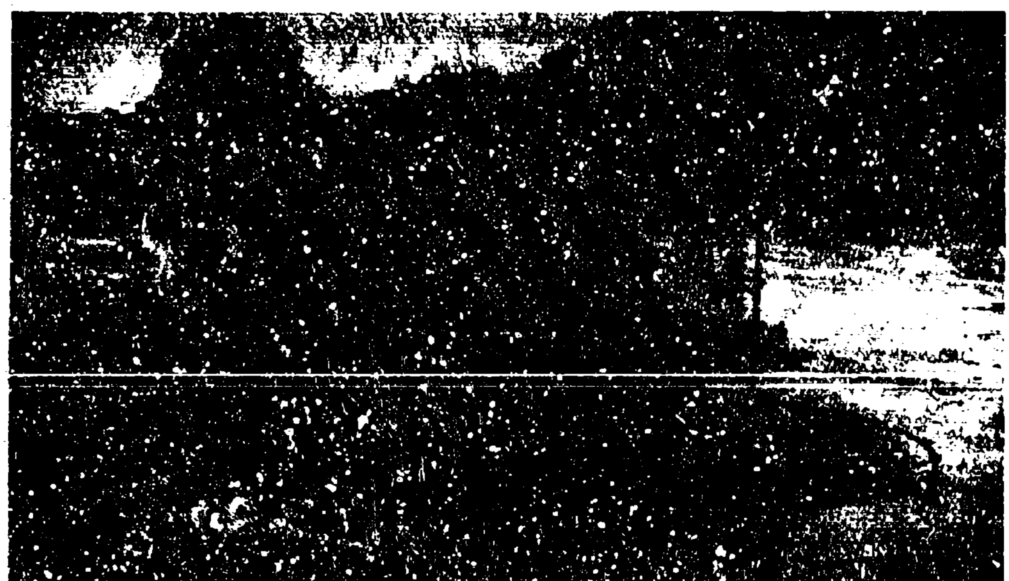


Figure 14. Top of AFWL Structure S-1, Upside Down for Instrumentation Placement, HANDEC I.

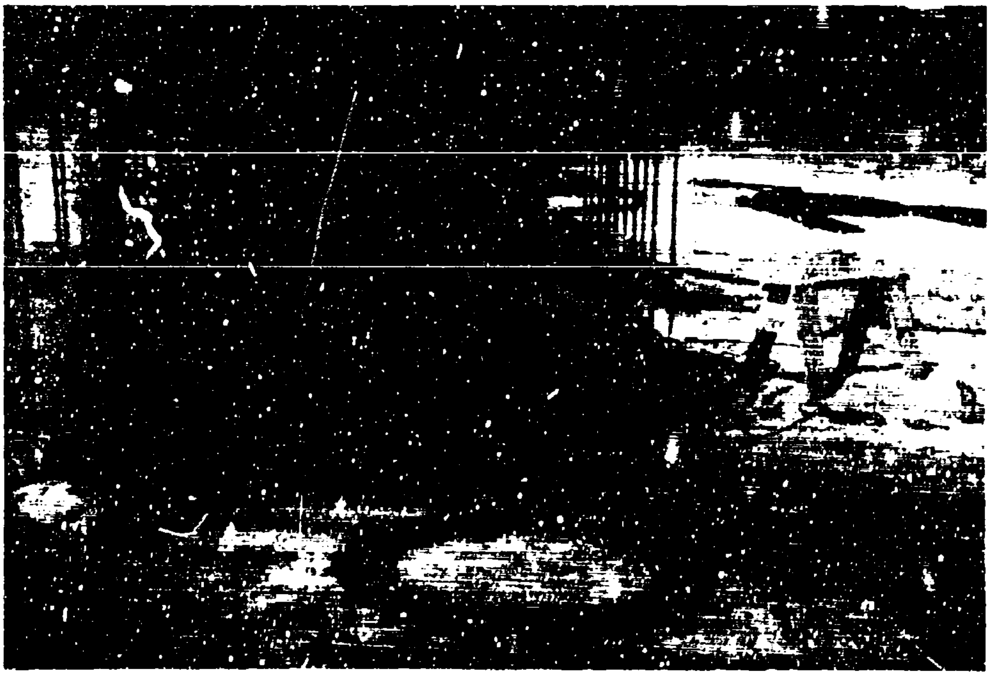


Figure 15. Top of AFWL Structure S-2, Upside Down for Ease of Instrumentation Installation. HANDEC I.

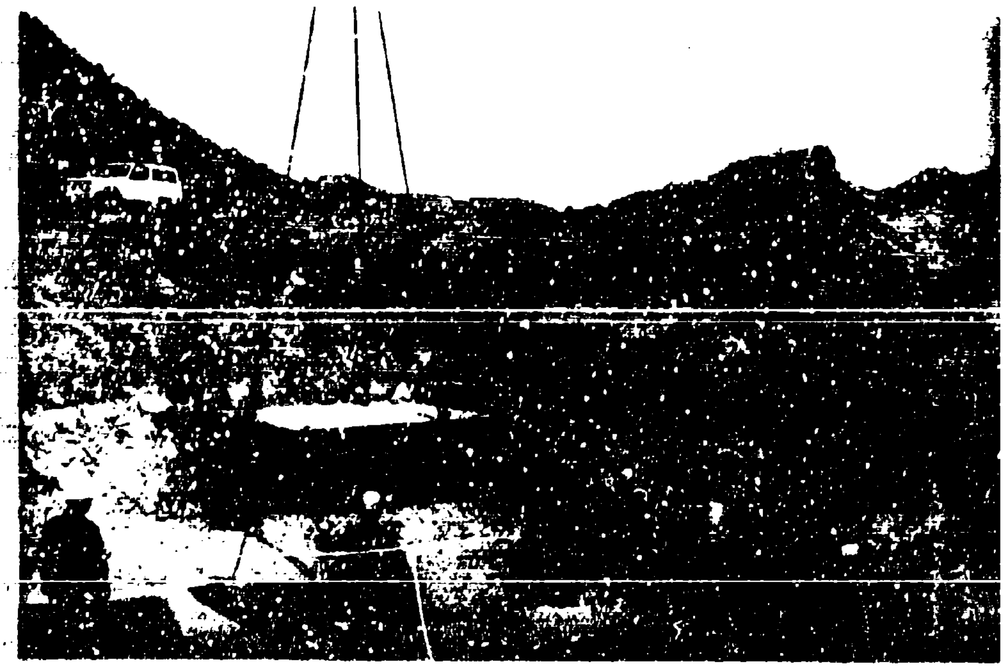


Figure 16. Removing Unlined Silo Closure in the HANDEC I Test Bed, Post Test.

Figure 17. HANDEC I Test Bed, Research Models and Columns.

Figure 18. CERF Installing Instrumentation. Contractor Erecting Columns and Beams for HANDEC I.

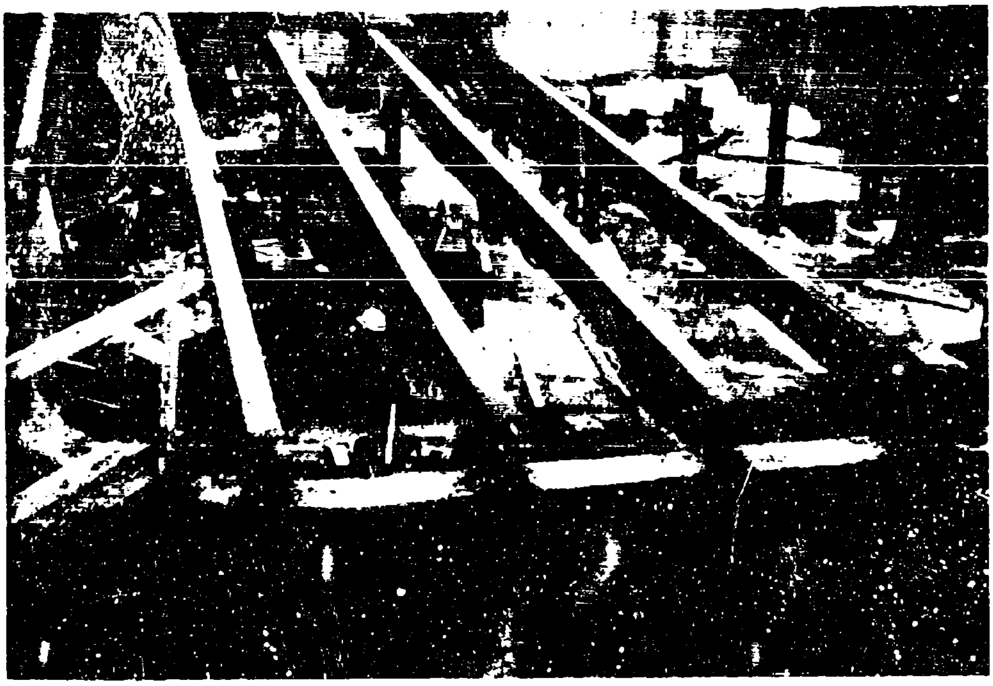


Figure 19. HANDEC I Test Bed, Showing Concrete Walls, Beams, Columns and Test Model Locations.

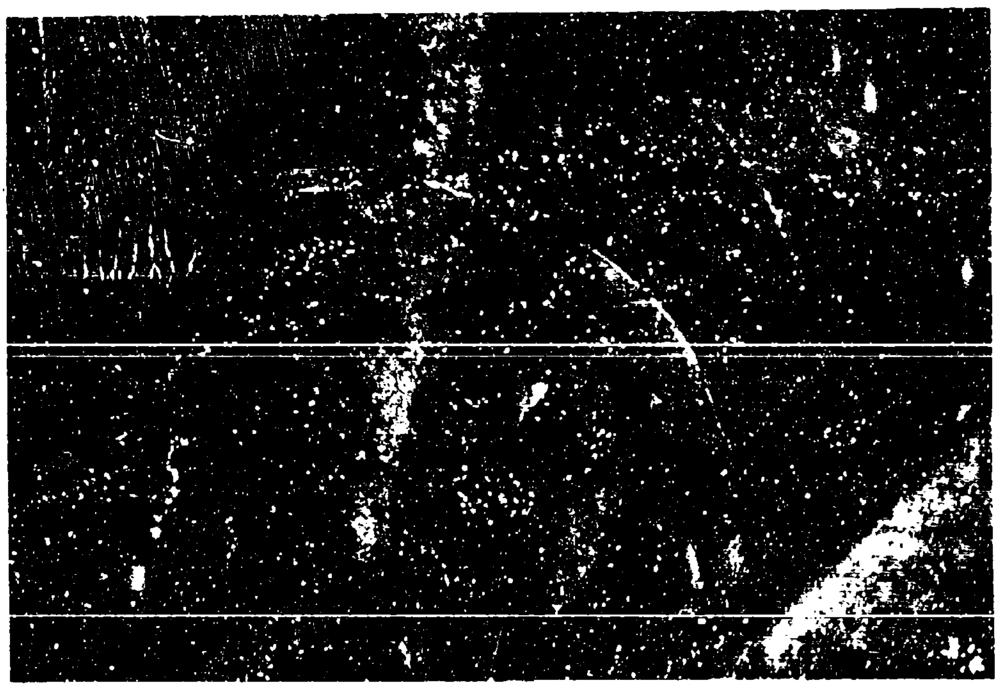


Figure 20. HANDEC I Unlined Silo Showing Instrumentation Holes Drilled into Rock.

Figure 21. HANDEC I Instrumentation Trench.

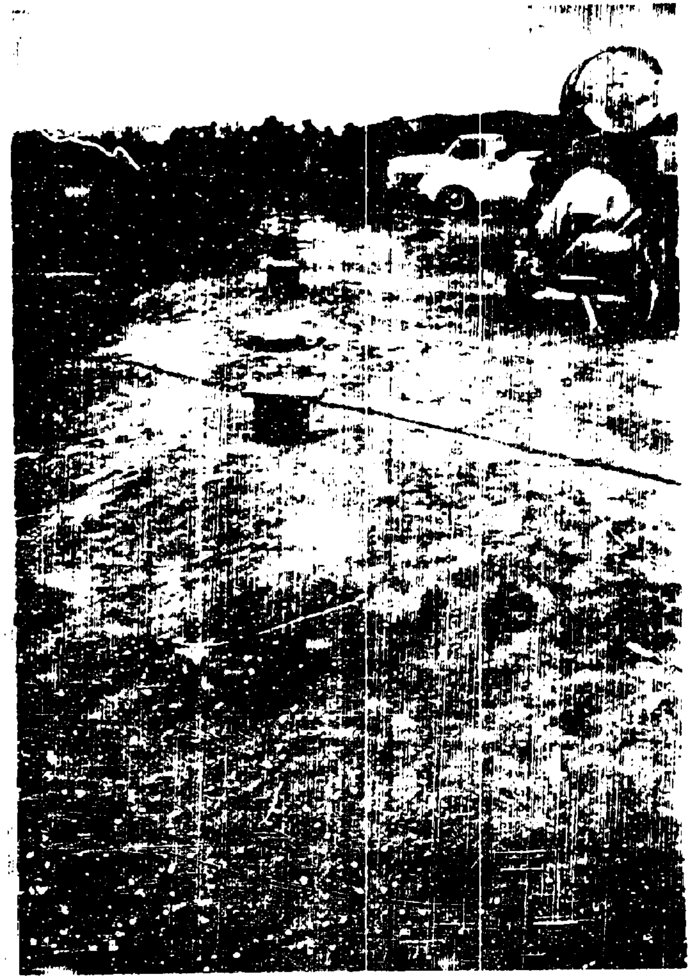


Figure 22. DIHEST Holes Steel Cased in Upper 10 Feet for HANDEC I DIHEST Explosives.

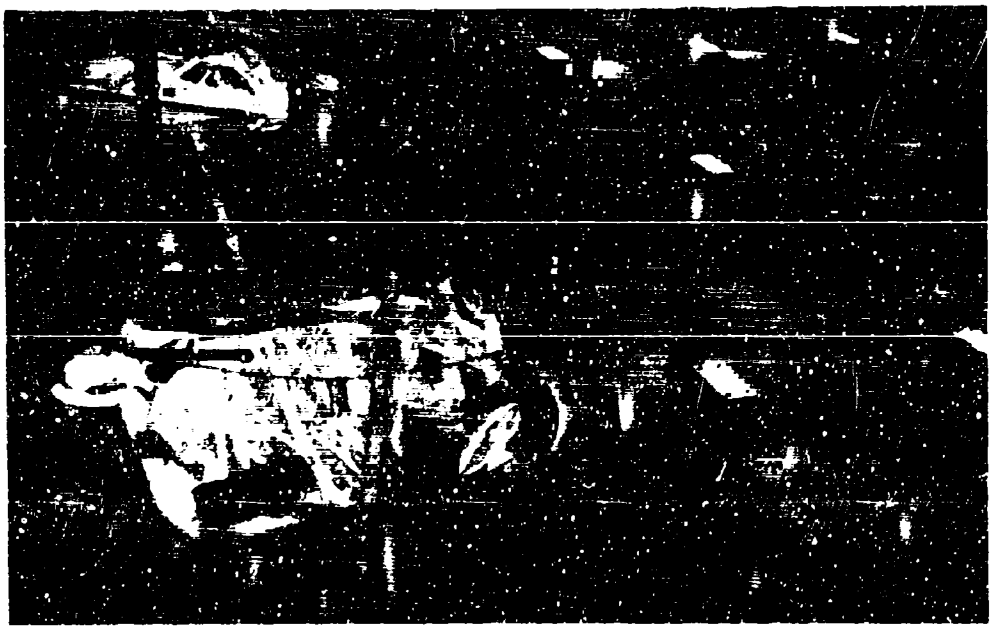


Figure 23. HANDEC I Test Bed Showing Model Locations, Columns and Instrumentation Trenches.

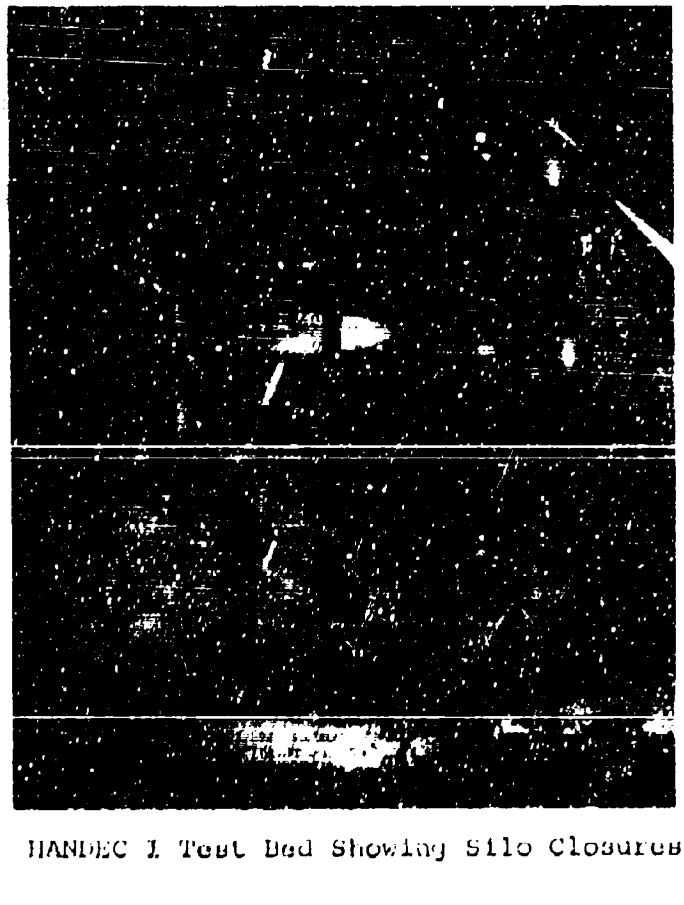


Figure 24. HANDEC I Test Bed Showing Silo Closures in Place.

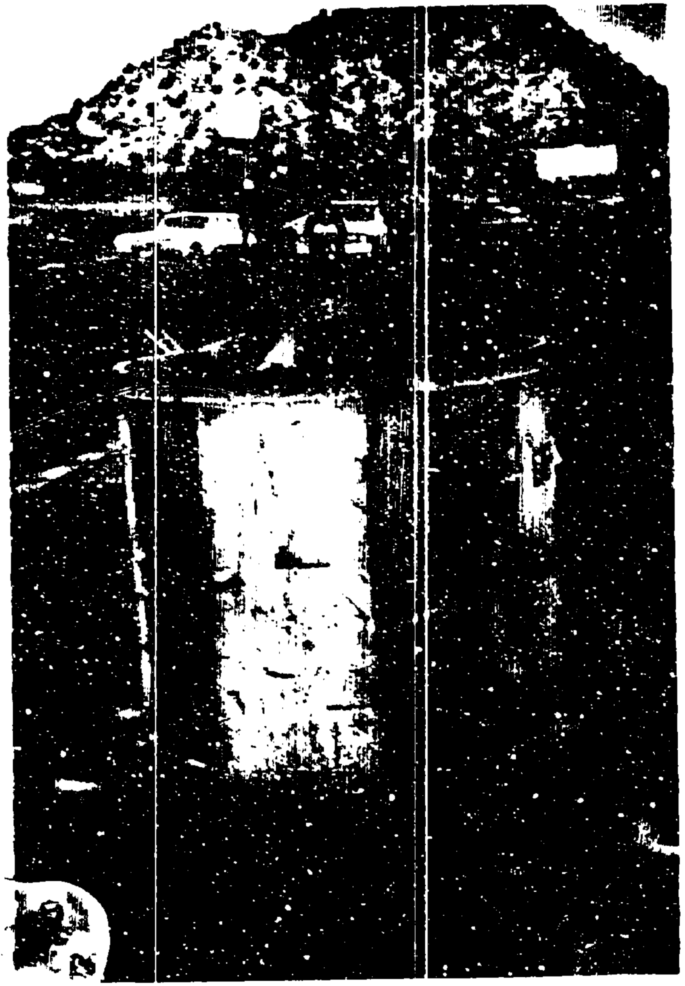


Figure 25. Pouring Concrete Cap Over Instrumentation Cable Exterior to Pit on HANDEC I.

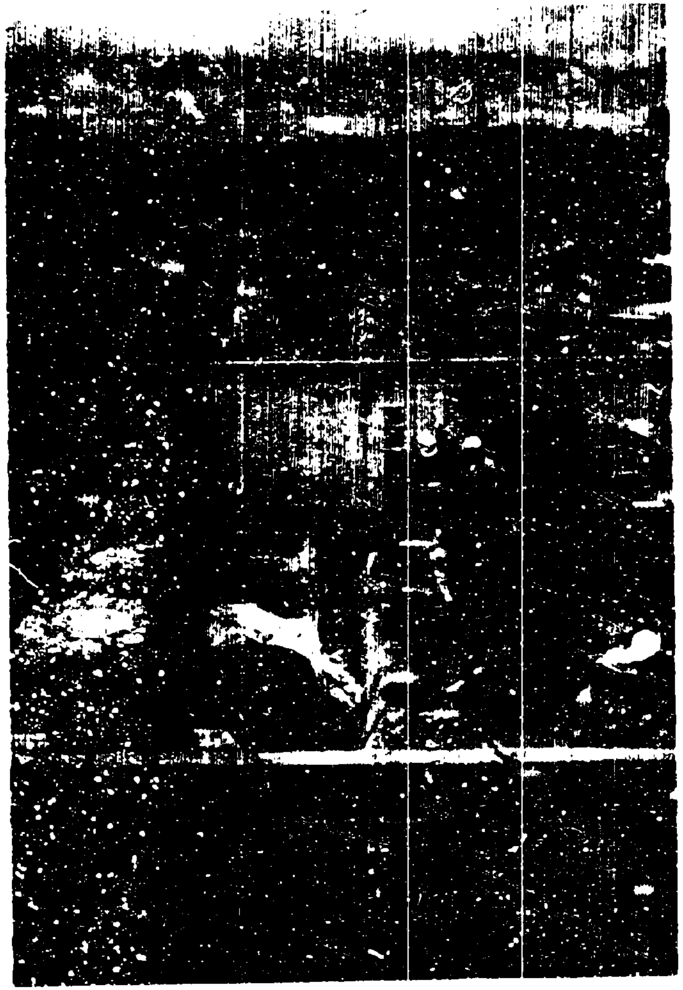


Figure 26. HANDEC I Instrumentation Cable Protective System in Trench.

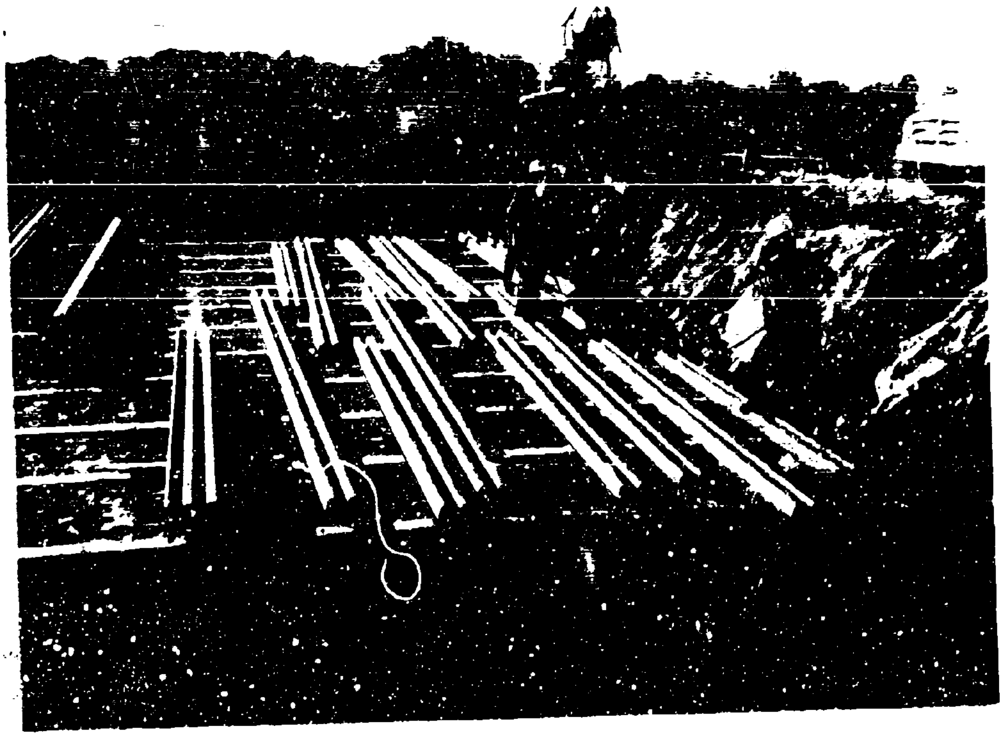


Figure 27. Earth Fill Between Steel Beams Prior to Structural Steel Deck Installation, HANDEC I.

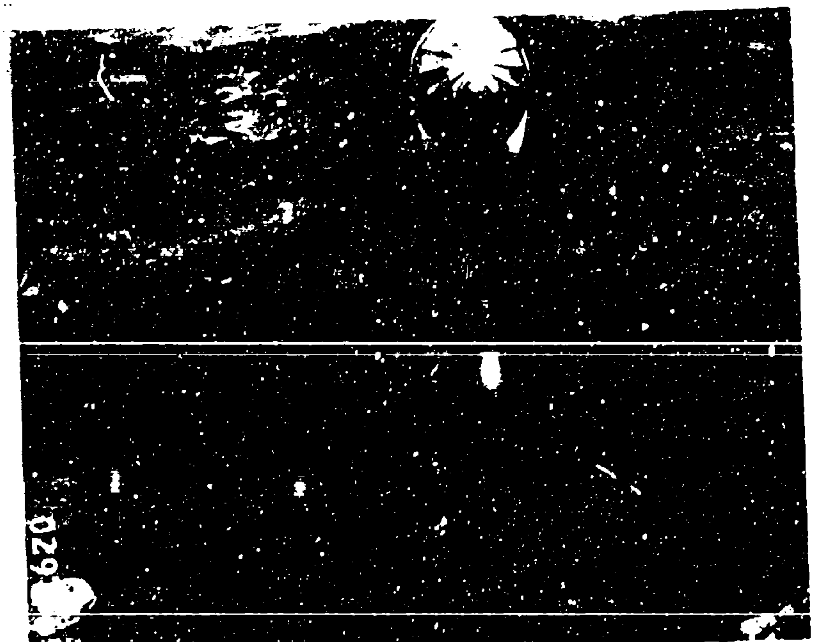


Figure 28. Installation of Firing System for DIHEST, HANDEC I.

Figure 29. Detonating Cord Wrapped on Wood Racks and Supported on Wood Rack Supports for HANDEC I.

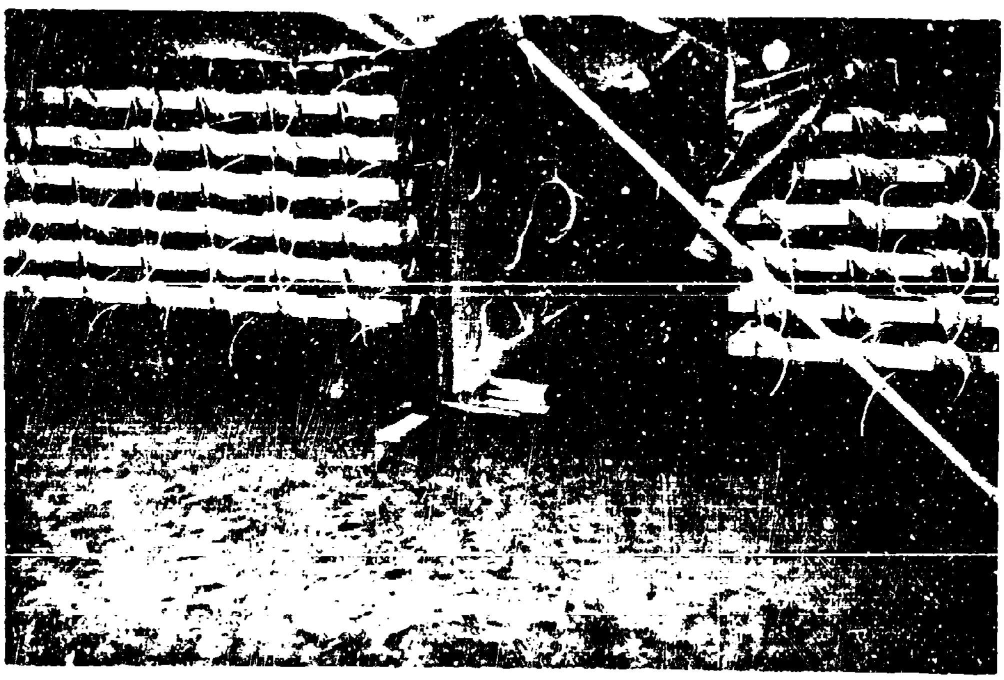


Figure 30. Detonating Cord and Planewave Generator Distribution Panels, HANDEC I.

Figure 31. Placing Detonating Cord in Test Bed for the HANDEC 1 Test.

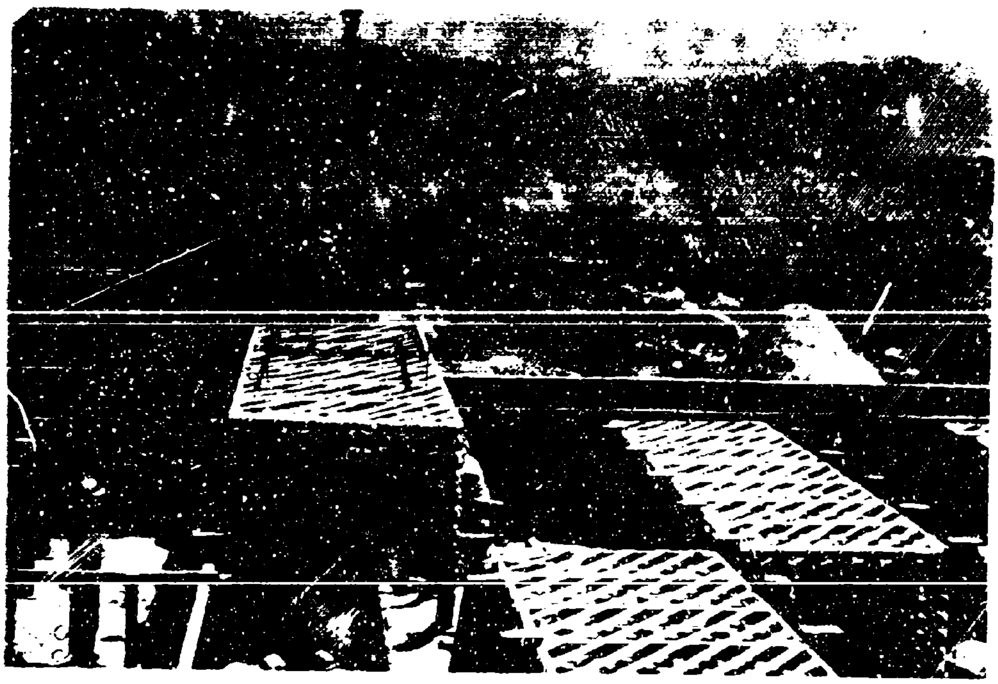


Figure 32. Detonating Cord Placement Between Columns, HANDEC 1.

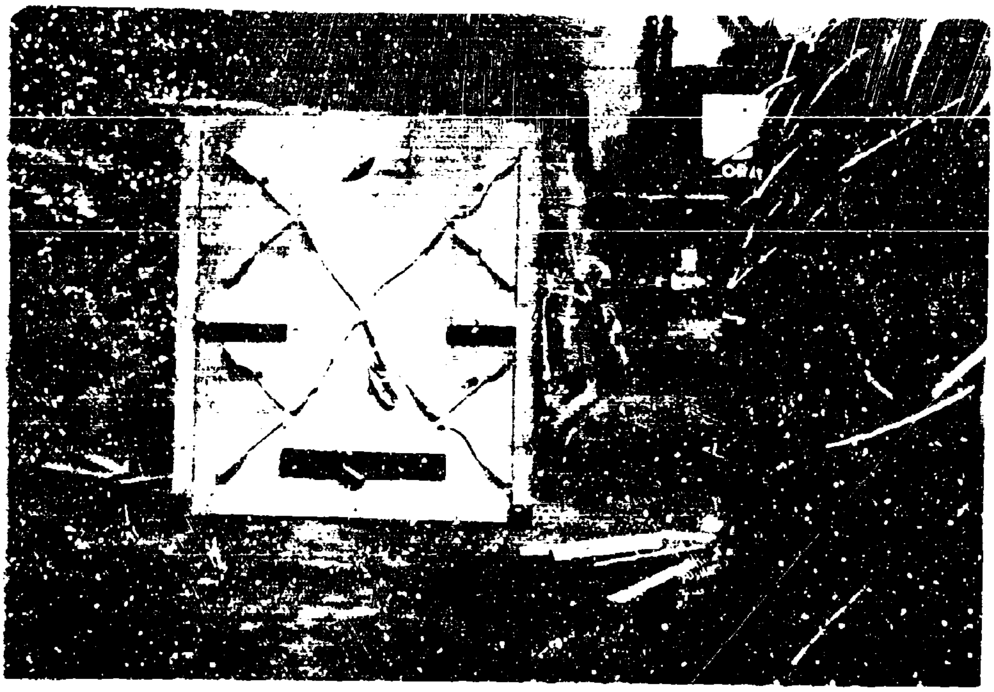


Figure 33. HANDEC I Planewave Generator Distribution Panel. Horizontal Ties on Racks Shown on Right Side of Photo.

Figure 34. Construction of Earth Berms and Surcharge Over the HANDEC I Structure.

Figure 35. Construction of the HEST Berm for HANDEC I.

Figure 36. HANDEC I Test Event at Cedar City, May 29, 1969.

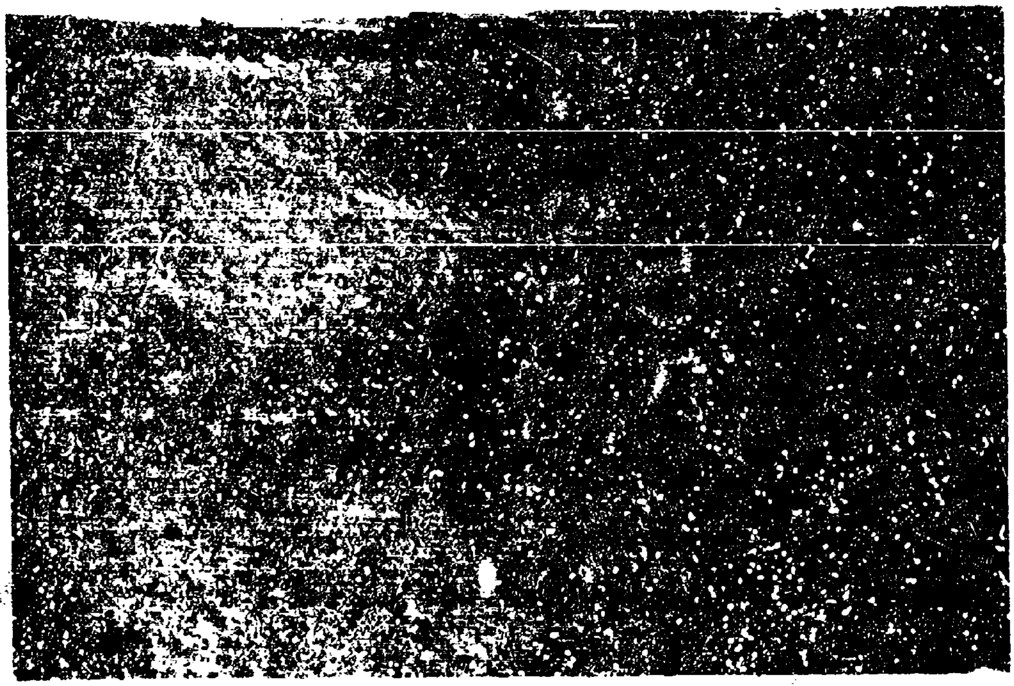


Figure 37. HANDEC I after Test Event.

Figure 38. HANDEC II Test Bed Filled with Debris from the HANDEC I Test Event.

Figure 39. Contractor Cleaning the HANDEC II Test Bed.

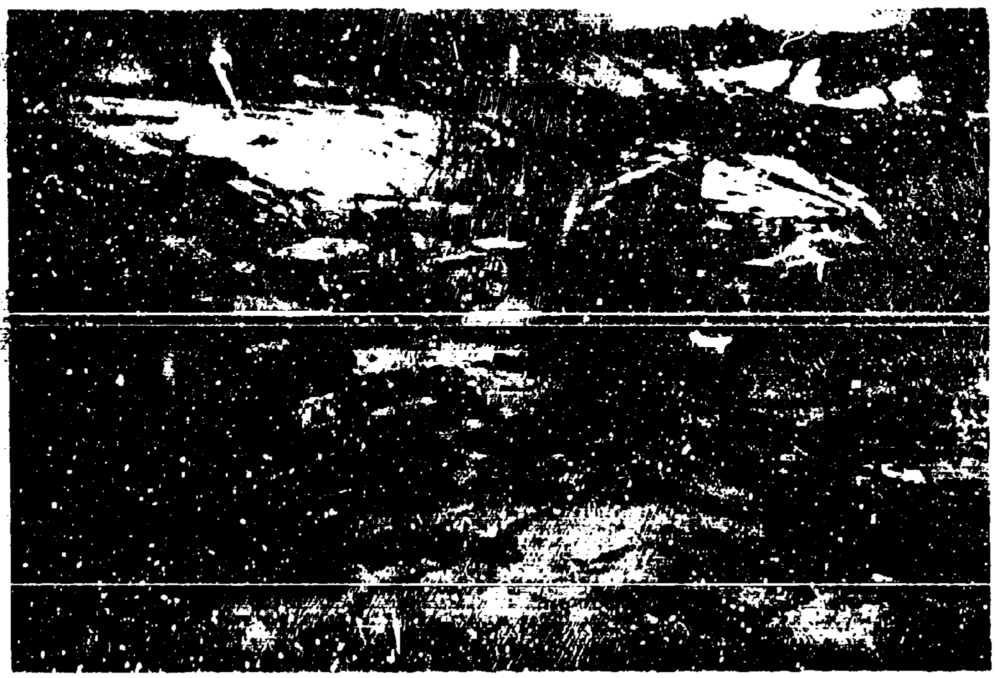


Figure 40. Corps of Engineers Rock Drilling in the HANDEC II Test Bed.

Figure 41. Corps of Engineers and Contractor Drill Rigs. HANDEC II Test Bed.

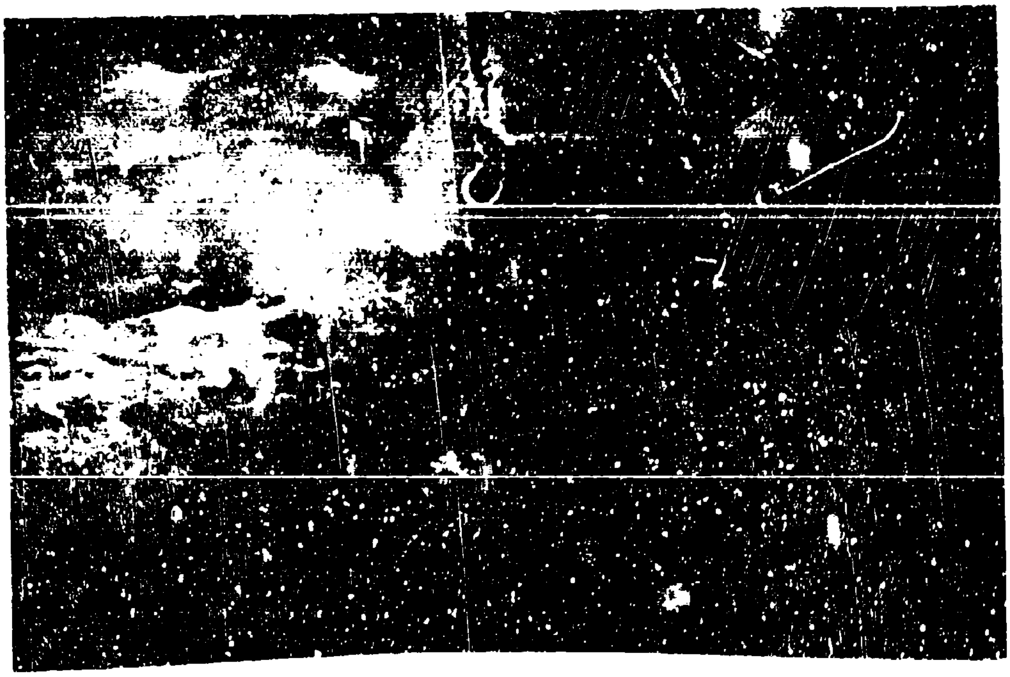


Figure 42. Contractor Drill Rig Drilling Rock Relief Holes for Blasting Instrumentation Trenches.

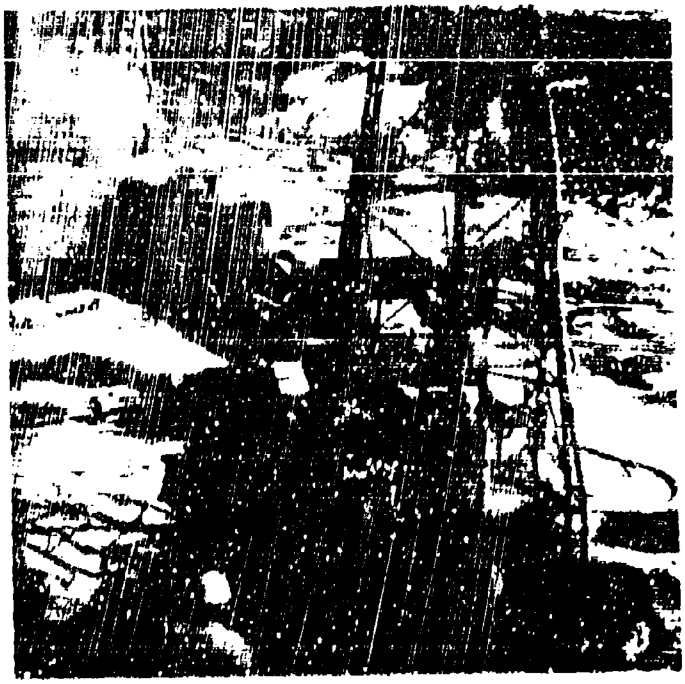


Figure 43. Corps of Engineers Rock Drilling HANDEC II Test Bed, March 1969.

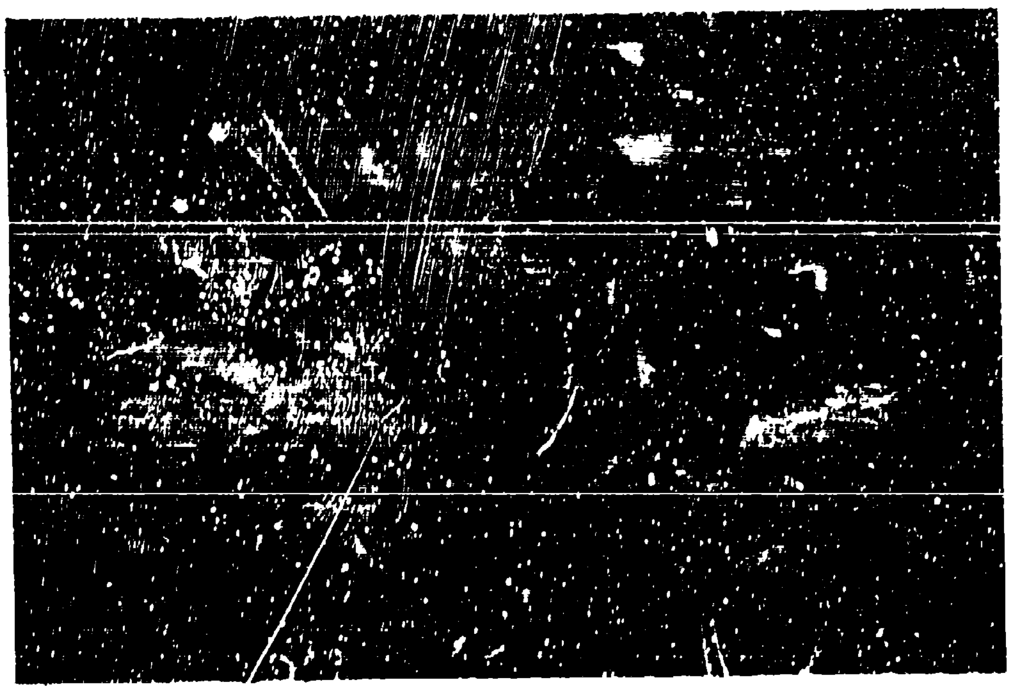


Figure 44. Excavation of Rock for AFWL Research Closures, Trenches and Structures, HANDEC II.

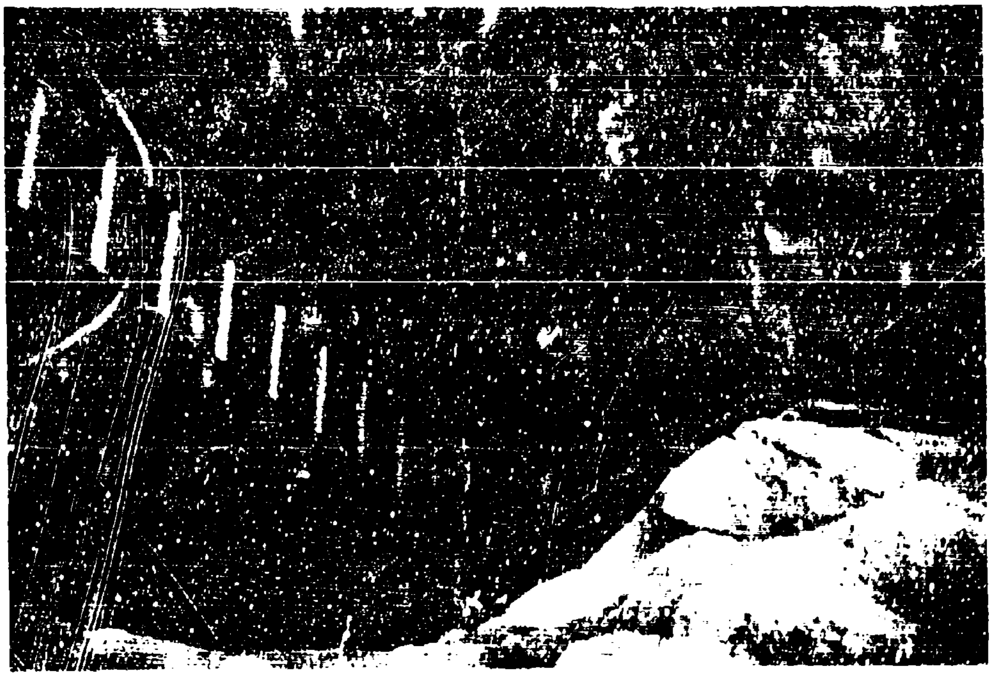


Figure 45. HANDEC II Rock Excavation for Lined Silo.

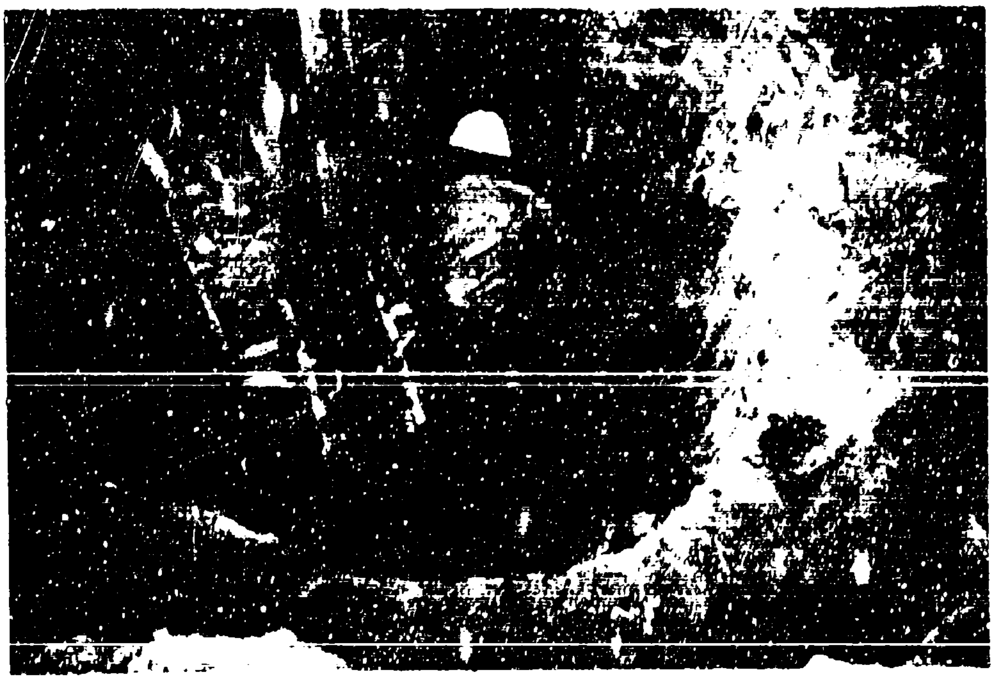


Figure 46. Rock Excavation-Lined Silo. HANDEC II.

Figure 47. HANDEC II Research Model Showing out of Level on Bearing Ring Received from Steel Fabricator.

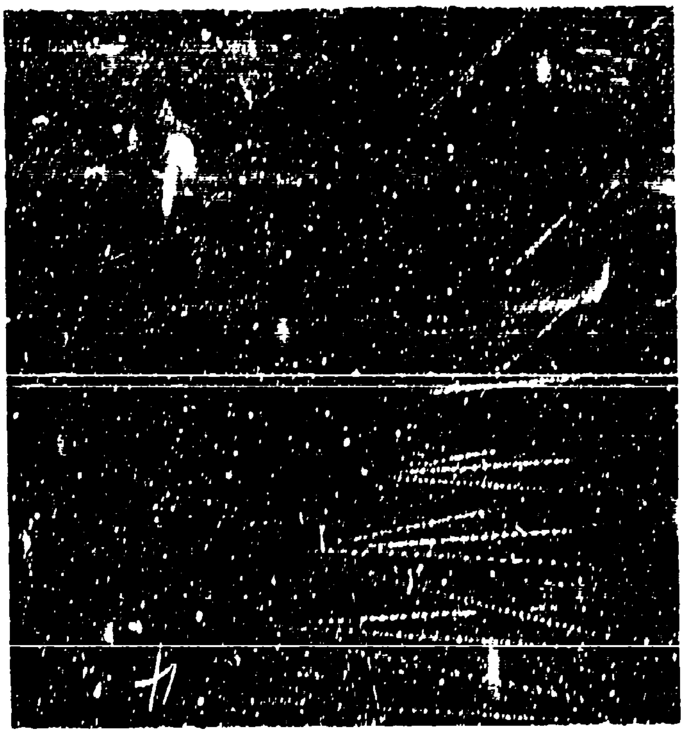


Figure 48. HANDEC II Test Models. Welded Splice in Bearing Ring Received from Fabricator.

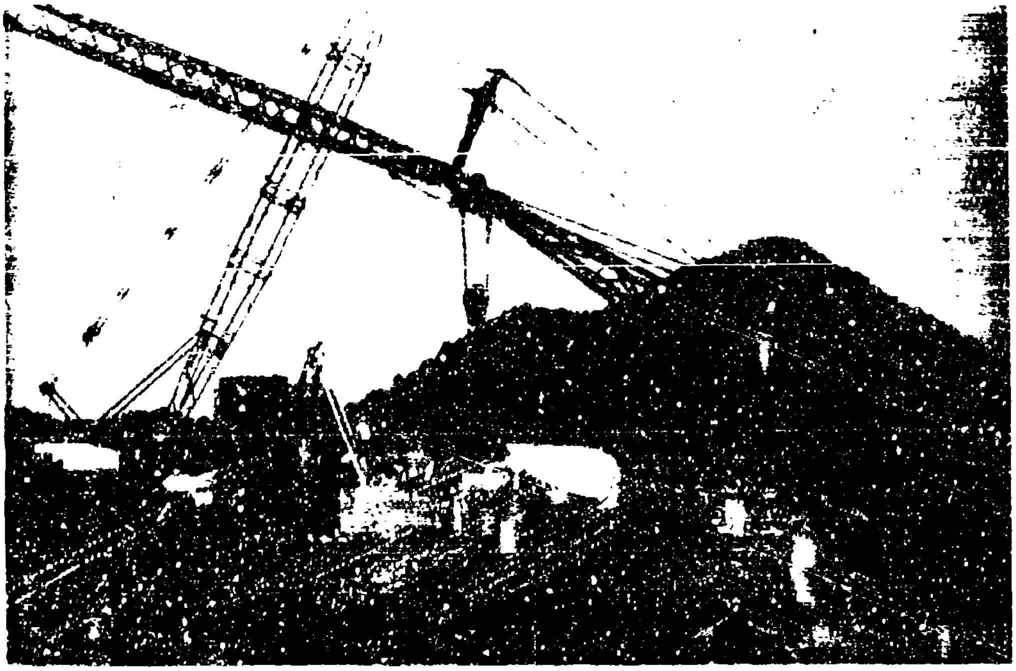


Figure 49. Research Models and Silo Shells, HANDEC II.

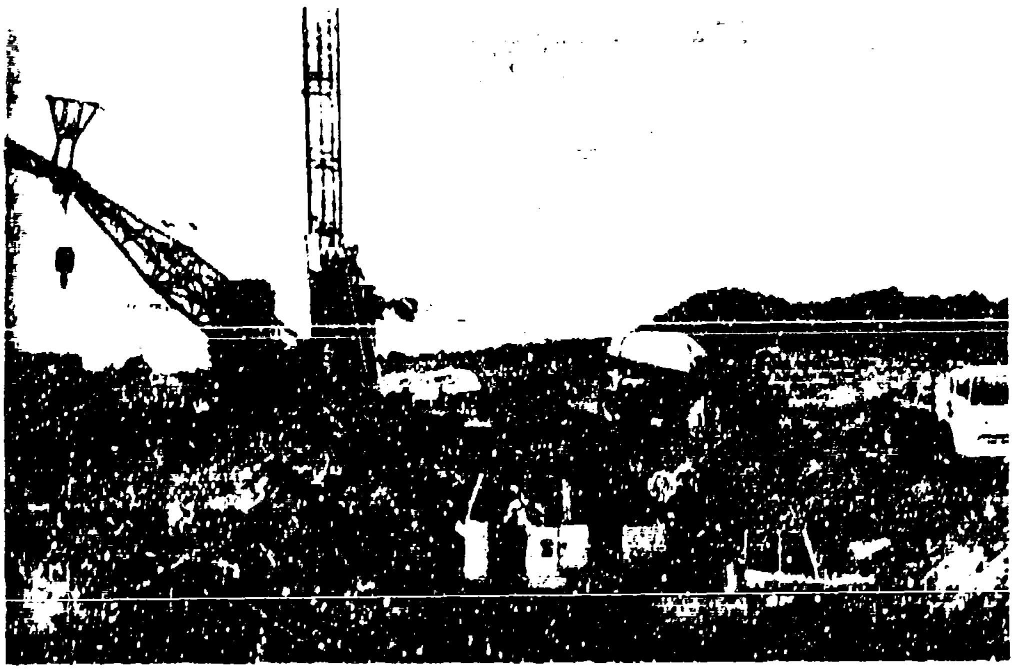


Figure 50. Contractor Preparing to Place Structures into Rock Test Bed, HANDEC II.

Figure 51. Lifting AFWL Lined Backpacked Silo Number 12 for Placement in Test Bed, HANDEC II.

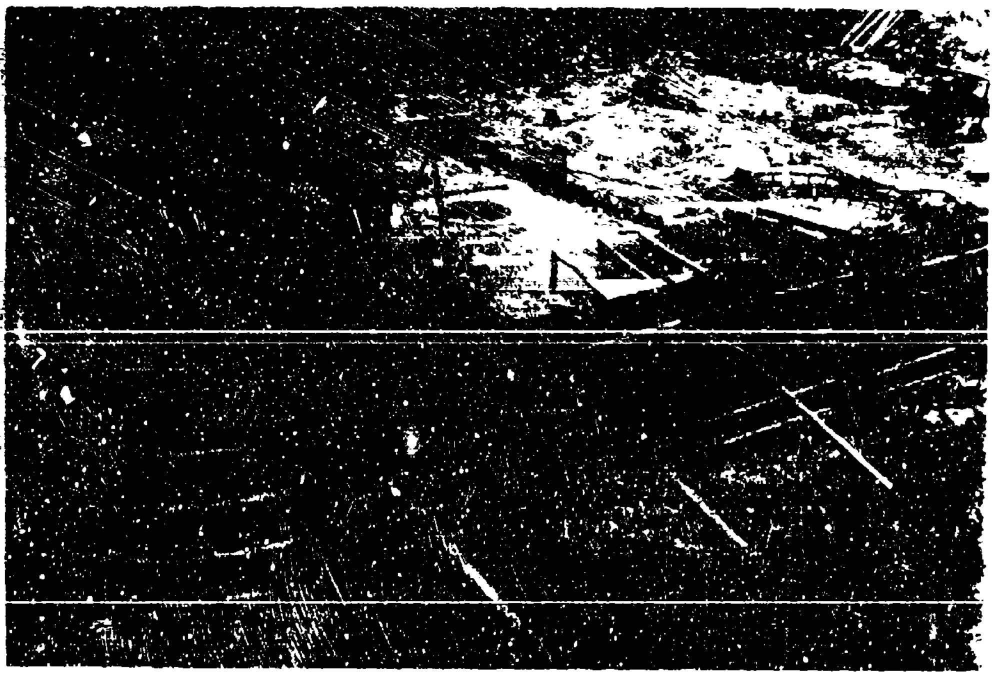


Figure 52. Lowering Lined Backpacked Silo Number 12 into Rock Excavation, HANDEC II.

Figure 53. Setting Lined Backpacked Silo Number 12 into HANDEC II Rock Excavation.

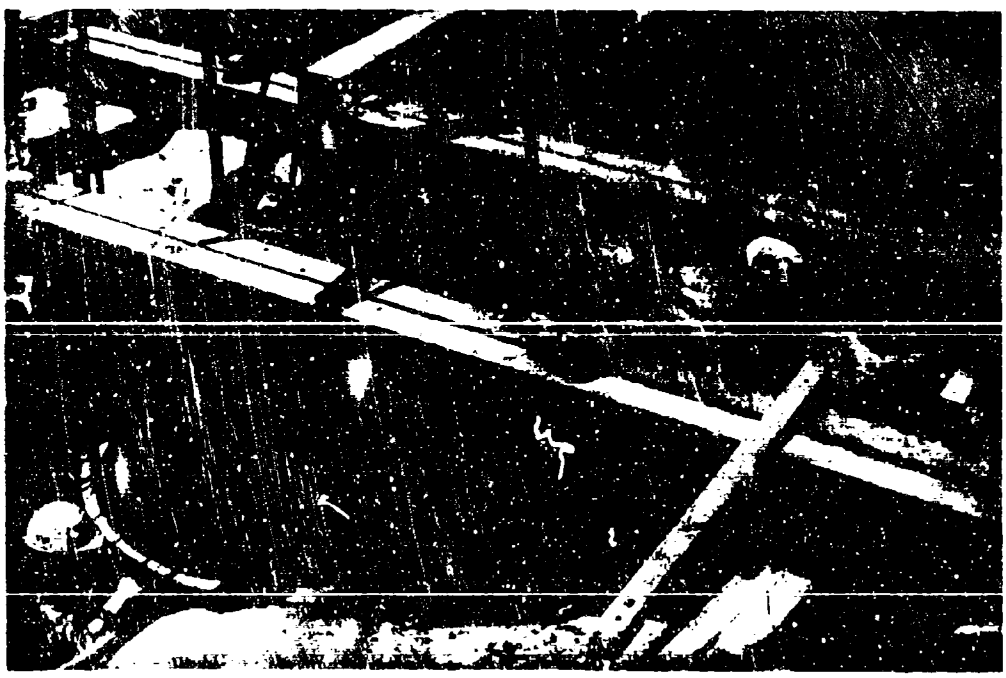


Figure 54. Final Alignment Lined Backpacked Silo Number 12. HANDEC II.

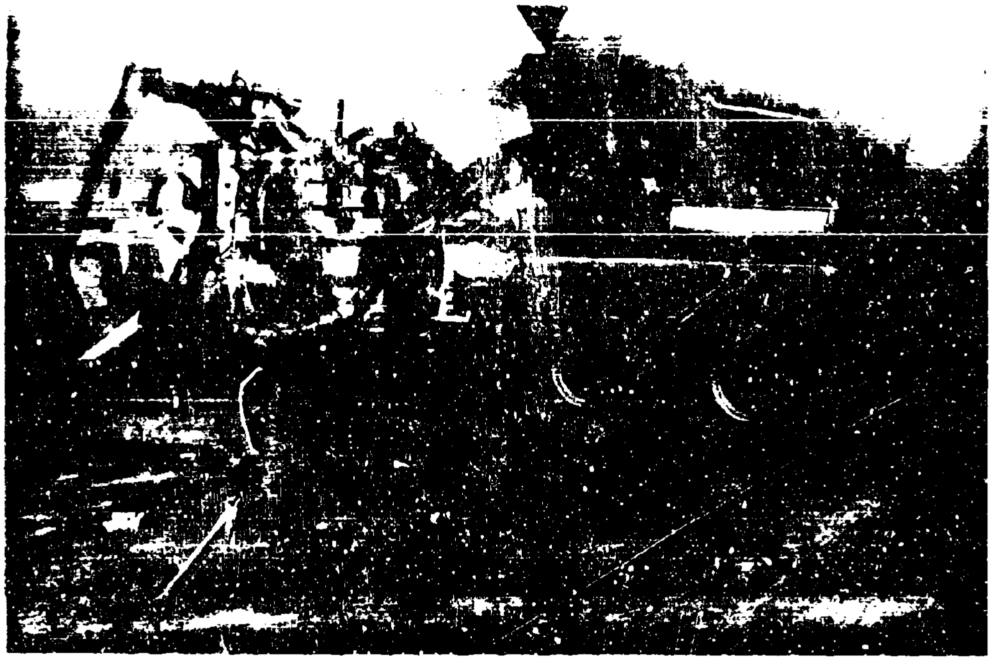


Figure 55. Mixing, Pumping and Placing of Backpacking Material Used on Silo Number 12, HANDEC II.

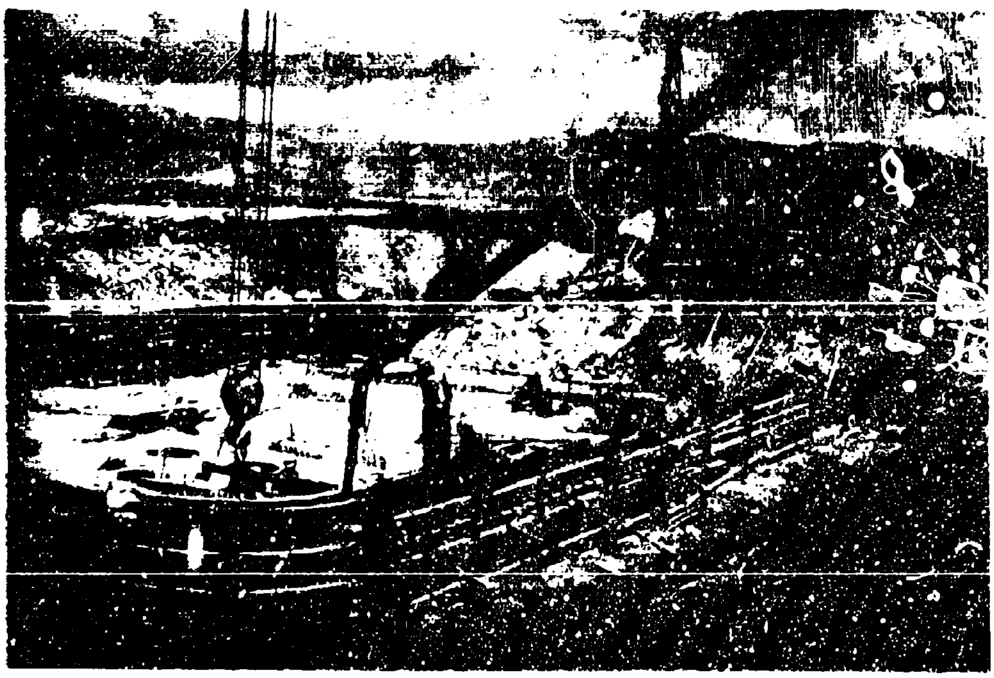


Figure 56. Backpacking Operation Around AFWL Silo Number 12, HANDEC II.

Figure 57. Placing Detonating Cord in HANDEC II.

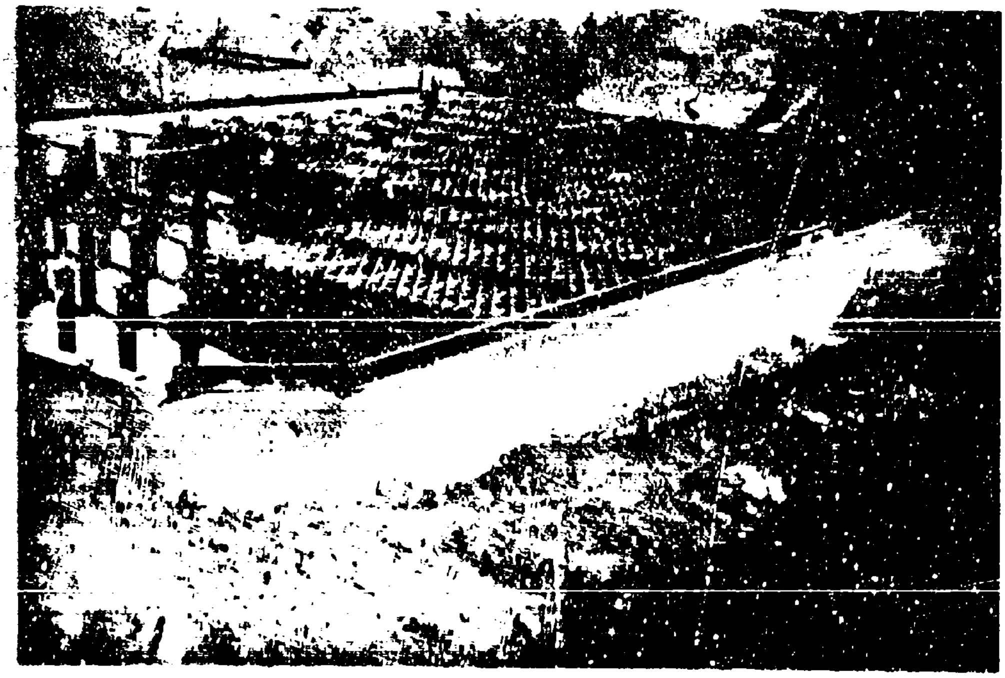


Figure 58. HANDEC II Test Bed Prior to Placing Steel Beams.

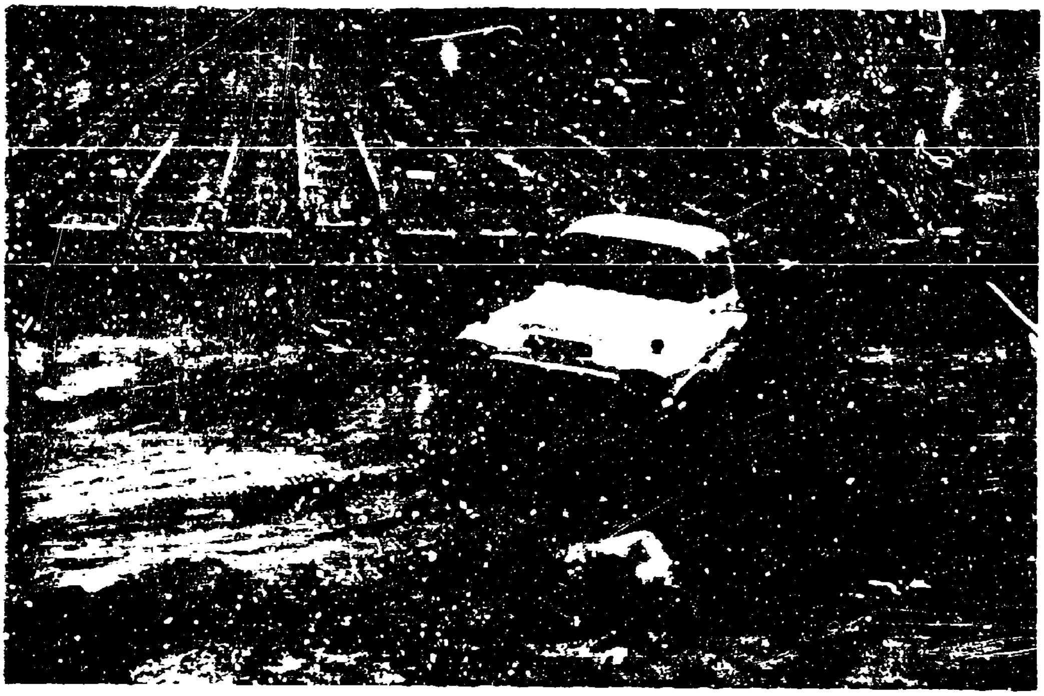


Figure 59. HANDEC II Test Bed. Beams Placed over Detonating Cord Prior to Erection of Subdeck and Decking.

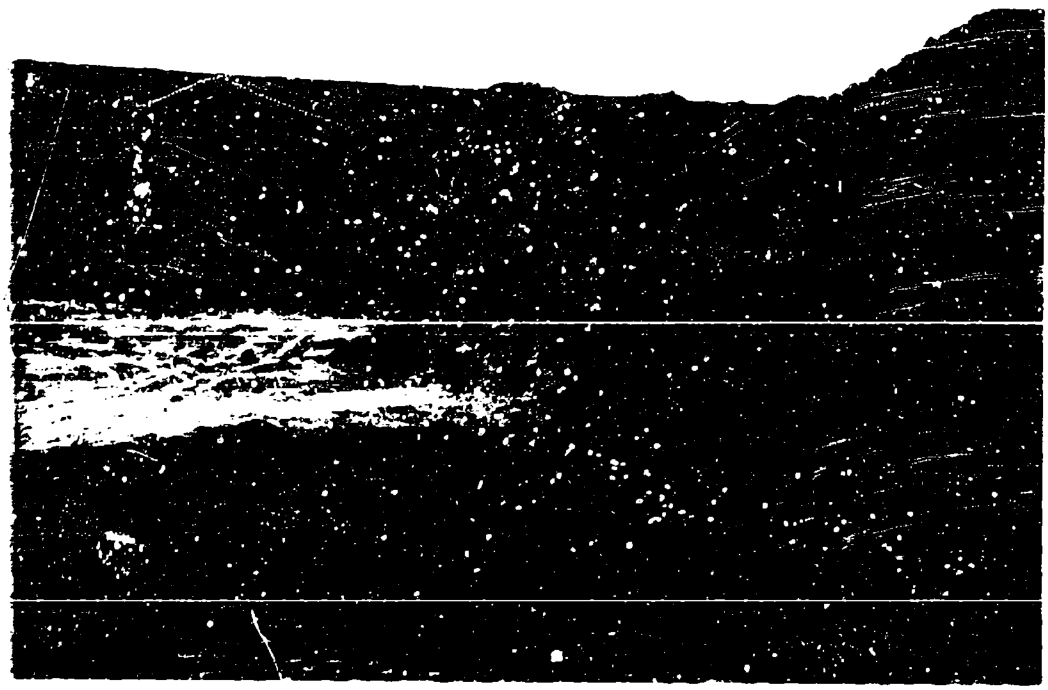


Figure 60. HANDEC II Prior to Test Event.

Figure 61. HANDEC II Test Event, August 14, 1969.

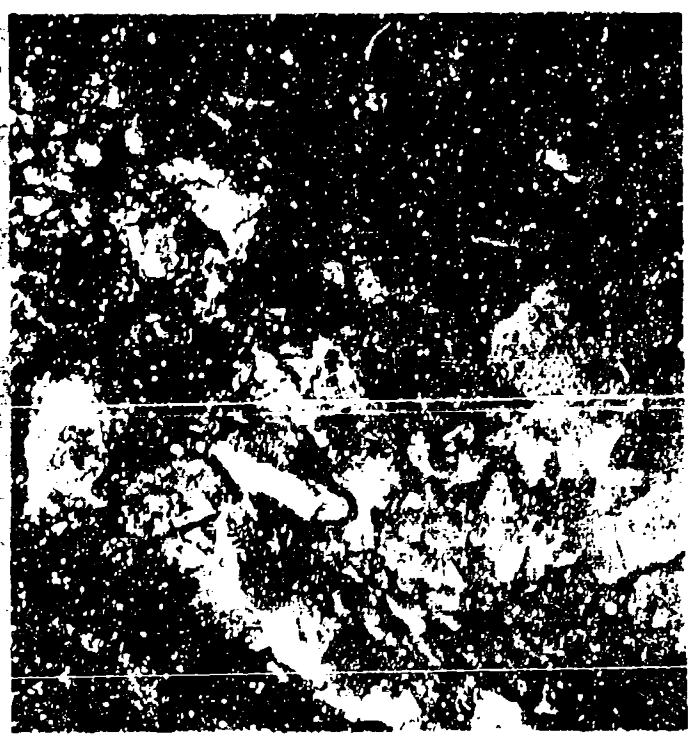


Figure 62. DIHEST Berm after the HANDEC II Shot.

APPENDIX III

CONSTRUCTION DRAWINGS HANDEC I

This appendix contains the following drawings:

CONSTRUCTION DRAWINGS HANDEC I (cont'd)

PROJECT HANDEC I

CEDAR CITY TEST SITE

AIR FORCE WEAPONS LABORATORY (WLDC)
DEVELOPMENT DIVISION, CIVIL ENGINEERING BRANCH
KIRTLAND AIR FORCE BASE, NEW MEXICO 87117

Figure 63

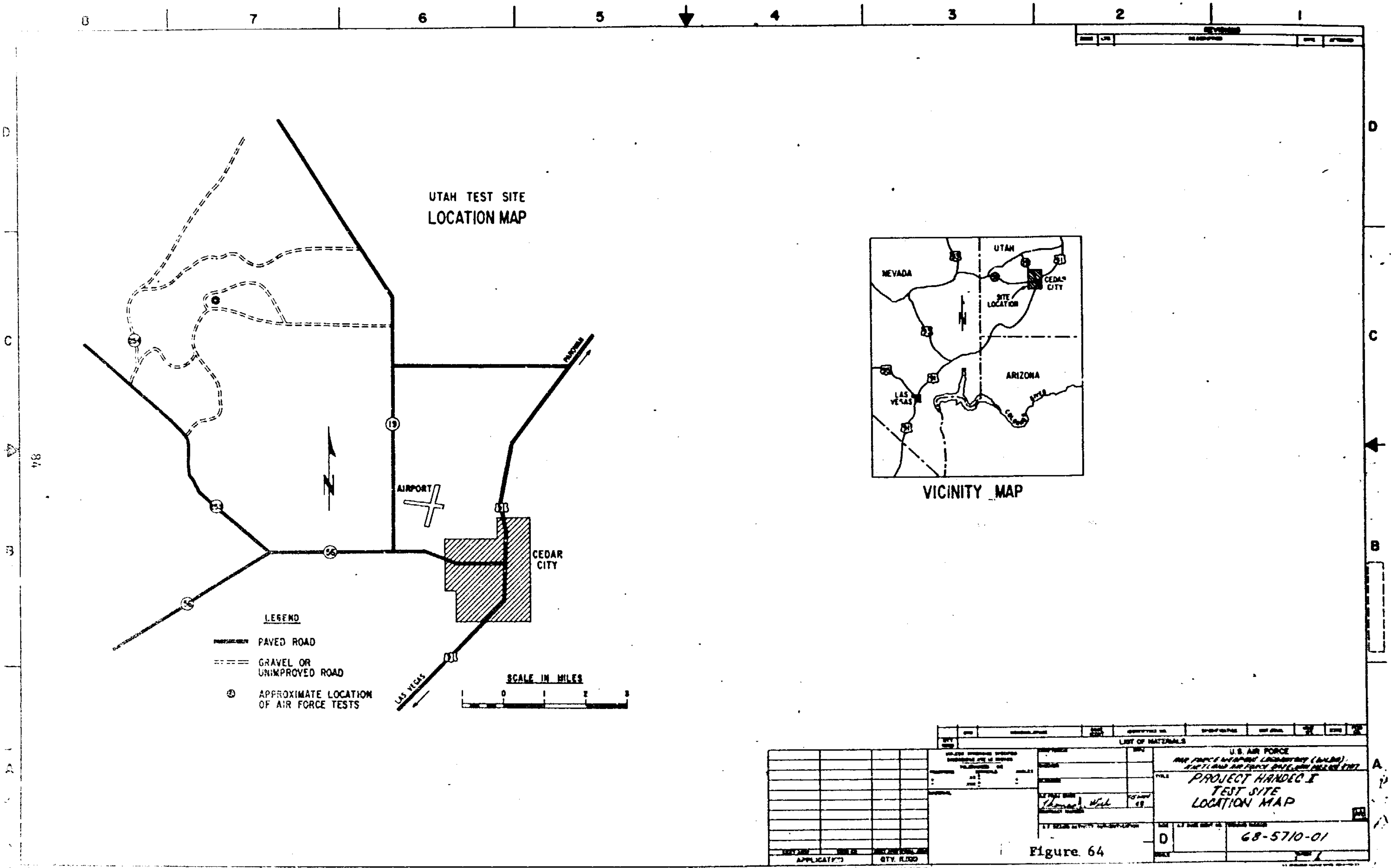

UTAH TEST SITE
LOCATION MAP
AIRPORT
CEDAR CITY
LAS VEGAS
LEGEND
PAVED ROAD
GRAVEL OR UNIMPROVED ROAD
APPROXIMATE LOCATION OF AIR FORCE TESTS
SCALE IN MILES
0 1 2 3
VICINITY MAP
NEVADA
UTAH
ARIZONA
CEDAR CITY
SITE LOCATION
LAS VEGAS
U.S. AIR FORCE
PROJECT HANDEC II
TEST SITE
LOCATION MAP
68-5710-01
LIST OF MATERIALS
APPLICATION
QTY. REQD

Figure 64

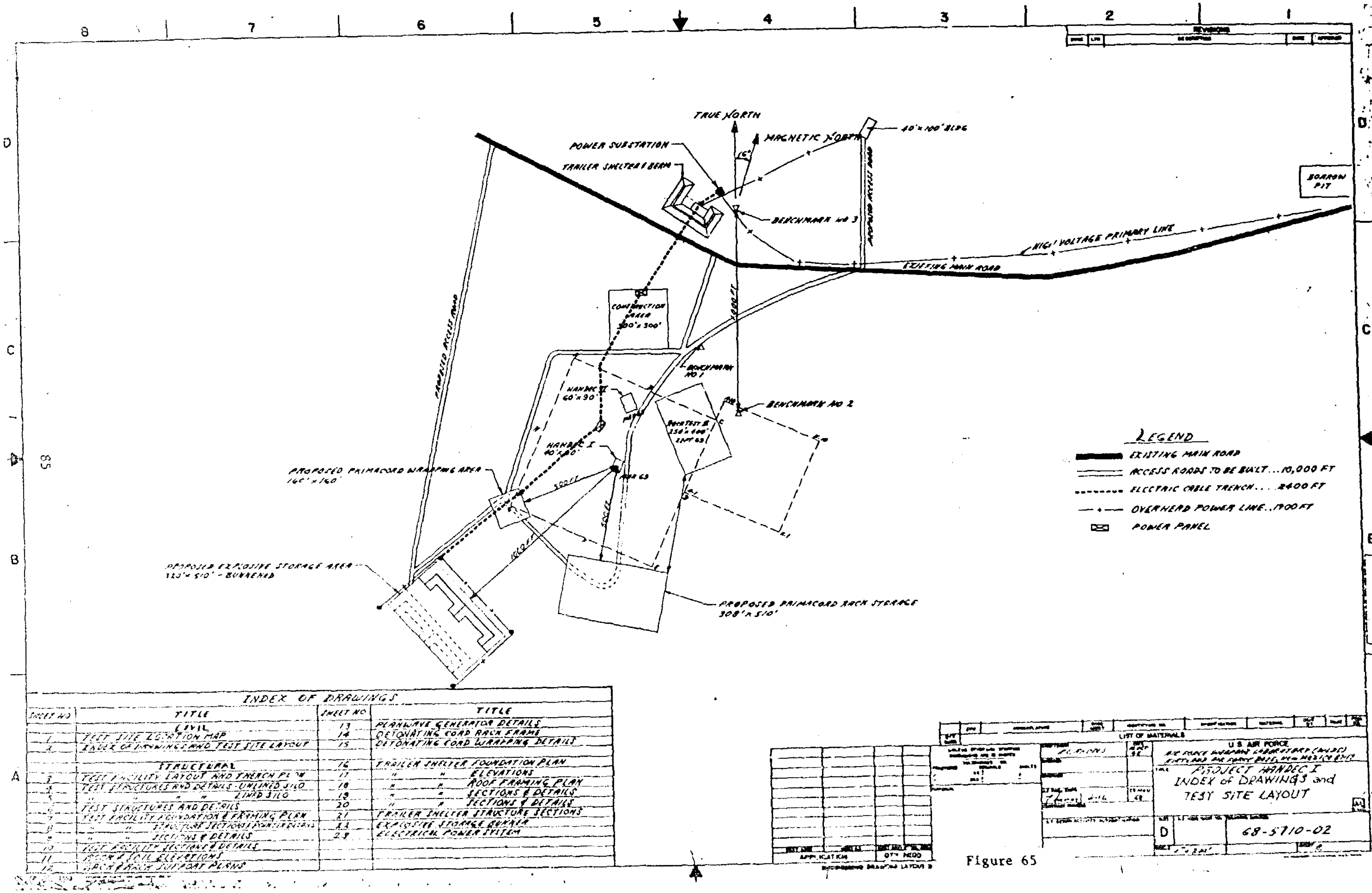
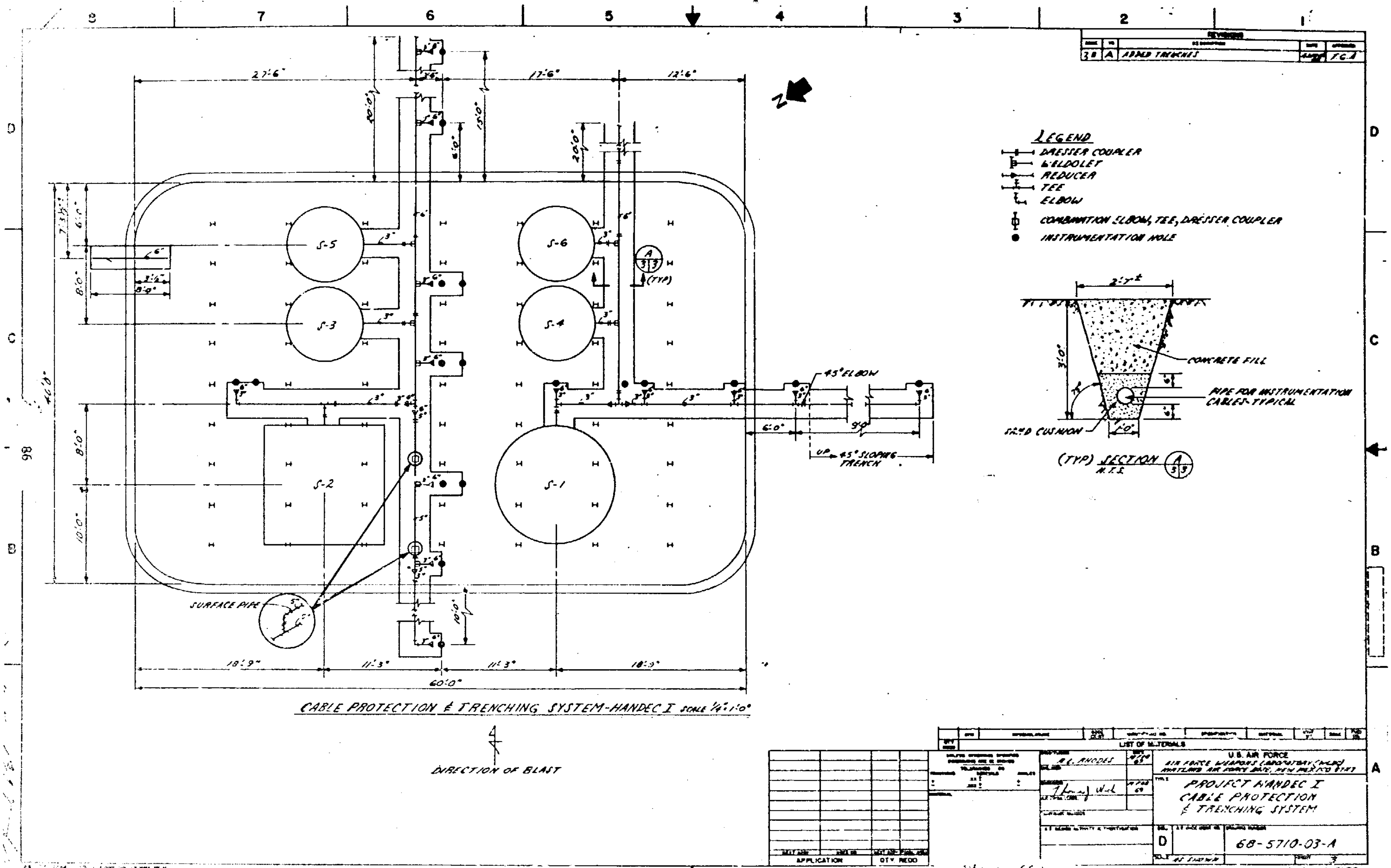

TRUE NORTH
MAGNETIC NORTH
40'x100' BLDG
POWER SUBSTATION
TRAILER SHELTER & BERM
BENCHMARK NO 3
BORROW PIT
HIGH VOLTAGE PRIMARY LINE
EXISTING MAIN ROAD
PROPOSED ACCESS ROAD
CONSTRUCTION AREA 300'x300'
BENCHMARK NO 1
BENCHMARK NO 2
HANDEC II 60'x90'
HANDEC I 40'x80'
PROPOSED PRIMACORD WRAPPING AREA 160'x160'
PROPOSED EXPLOSIVE STORAGE AREA 320'x510' - BUNKERED
PROPOSED PRIMACORD RACK STORAGE 308'x510'
LEGEND
EXISTING MAIN ROAD
ACCESS ROADS TO BE BUILT...10,000 FT
ELECTRIC CABLE TRENCH....2400 FT
OVERHEAD POWER LINE..1900 FT
POWER PANEL
INDEX OF DRAWINGS
SHEET NO | TITLE | SHEET NO | TITLE
CIVIL
1 TEST SITE LOCATION MAP
2 INDEX OF DRAWINGS AND TEST SITE LAYOUT
STRUCTURAL
3 TEST FACILITY LAYOUT AND TRENCH PLAN
4 TEST STRUCTURES AND DETAILS - UNLINED SILO
5 " " " " LINED SILO
6 TEST STRUCTURES AND DETAILS
7 TEST FACILITY FOUNDATION & FRAMING PLAN
8 " " STRUCTURE SECTIONS & DETAILS
9 " " SECTIONS & DETAILS
10 TEST FACILITY SECTIONS & DETAILS
11 ROOF & SOIL ELEVATIONS
12 RACK & RACK SUPPORT PLANS
13 PLANWAVE GENERATOR DETAILS
14 DETONATING CORD RACK FRAME
15 DETONATING CORD WRAPPING DETAILS
16 TRAILER SHELTER FOUNDATION PLAN
17 " " ELEVATIONS
18 " " ROOF FRAMING PLAN
19 " " SECTIONS & DETAILS
20 " " SECTIONS & DETAILS
21 TRAILER SHELTER STRUCTURE SECTIONS
22 EXPLOSIVE STORAGE BUNKER
23 ELECTRICAL POWER SYSTEM
REVISIONS
LIST OF MATERIALS
U.S. AIR FORCE
PROJECT HANDEC I
INDEX of DRAWINGS and
TEST SITE LAYOUT
D
68-5710-02

Figure 65



LEGEND
DRESSER COUPLER
WELDOLET
REDUCER
TEE
ELBOW
COMBINATION ELBOW, TEE, DRESSER COUPLER
INSTRUMENTATION HOLE
CONCRETE FILL
PIPE FOR INSTRUMENTATION CABLES-TYPICAL
SAND CUSHION
(TYP) SECTION A
N.T.S.
45° ELBOW
UP 45° SLOPING TRENCH
SURFACE PIPE
S-1
S-2
S-3
S-4
S-5
S-6
CABLE PROTECTION & TRENCHING SYSTEM-HANDEC I SCALE 1/4"=1'-0"
DIRECTION OF BLAST
ADDED TRENCHES
LIST OF MATERIALS
APPLICATION
QTY REQD
U.S. AIR FORCE
AIR FORCE WEAPONS LABORATORY (WLDC)
KIRTLAND AIR FORCE BASE, NEW MEXICO 87117
PROJECT HANDEC I
CABLE PROTECTION
& TRENCHING SYSTEM
D
68-5710-03-A

Figure 66

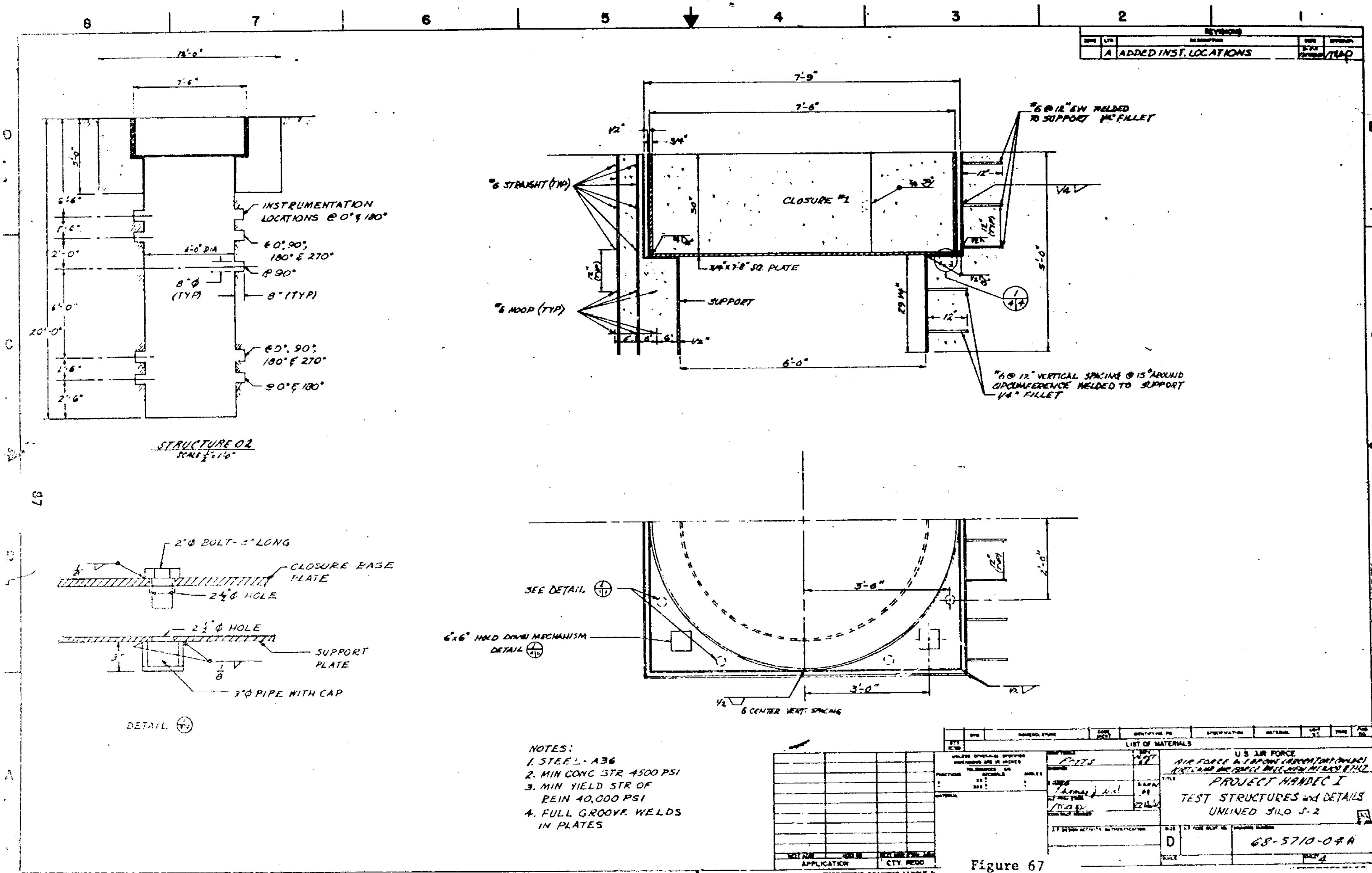
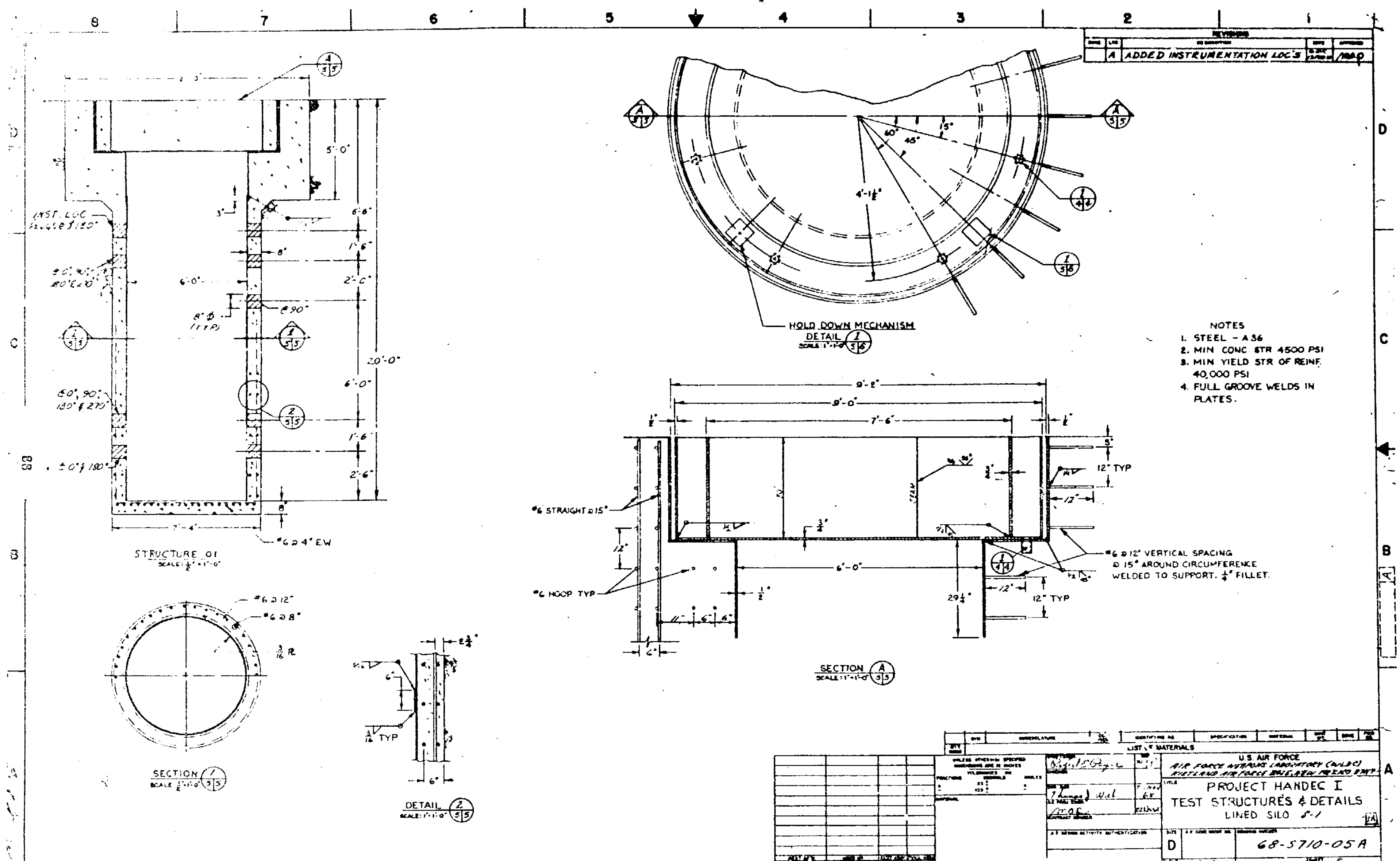

REVISIONS
A ADDED INST. LOCATIONS
7'-9"
7'-6"
1/2"
3/4"
#6 @ 12" EW WELDED TO SUPPORT 1/4" FILLET
#6 STRAIGHT (TYP)
CLOSURE #1
3/4"x7'-8" SQ. PLATE
SUPPORT
#6 HOOP (TYP)
6'-0"
5'-0"
#6 @ 12" VERTICAL SPACING @ 15° AROUND CIRCUMFERENCE WELDED TO SUPPORT 1/4" FILLET
13'-0"
7'-6"
INSTRUMENTATION LOCATIONS @ 0° & 180°
6'-0" DIA
@ 0°, 90°, 180° & 270°
@ 90°
8" Ø (TYP)
8" (TYP)
@ 0°, 90°, 180° & 270°
90° & 180°
20'-0"
5'-6"
1'-6"
2'-0"
6'-0"
1'-6"
2'-6"
STRUCTURE 02
2" Ø BOLT-4" LONG
CLOSURE BASE PLATE
2 1/4" Ø HOLE
2 1/2" Ø HOLE
SUPPORT PLATE
3" Ø PIPE WITH CAP
DETAIL
SEE DETAIL
6"x6" HOLD DOWN MECHANISM DETAIL
3'-6"
3'-0"
6'-0"
6 CENTER VERT. SPACING
NOTES:
1. STEEL - A36
2. MIN CONC STR 4500 PSI
3. MIN YIELD STR OF REIN 40,000 PSI
4. FULL GROOVE WELDS IN PLATES
LIST OF MATERIALS
U S AIR FORCE
PROJECT HANDEC I
TEST STRUCTURES and DETAILS
UNLINED SILO S-2
D
68-5710-04A
APPLICATION
ENGINEERING DRAWING LAYOUT D

Figure 67



REVISIONS
A ADDED INSTRUMENTATION LOC'S
NOTES
1. STEEL - A36
2. MIN CONC STR 4500 PSI
3. MIN YIELD STR OF REINF. 40,000 PSI
4. FULL GROOVE WELDS IN PLATES.
HOLD DOWN MECHANISM
DETAIL
4'-1½"
60°
45°
15°
9'-2"
9'-0"
7'-6"
6'-0"
29¼"
12" TYP
#6 @ 12" VERTICAL SPACING
@ 15° AROUND CIRCUMFERENCE
WELDED TO SUPPORT. ¼" FILLET.
#6 STRAIGHT @ 15°
#6 HOOP TYP
SECTION
STRUCTURE 01
20'-0"
5'-0"
6'-6"
1'-6"
2'-0"
6'-0"
1'-6"
2'-6"
7'-4"
#6 @ 4" EW
INST. LOC
#6 @ 12"
#6 @ 8"
SECTION
DETAIL
TYP
APPLICATION
QTY REQD
LIST OF MATERIALS
U.S. AIR FORCE
PROJECT HANDEC I
TEST STRUCTURES & DETAILS
LINED SILO S-1
D
68-5710-05A
AS SHOWN
5

Figure 68

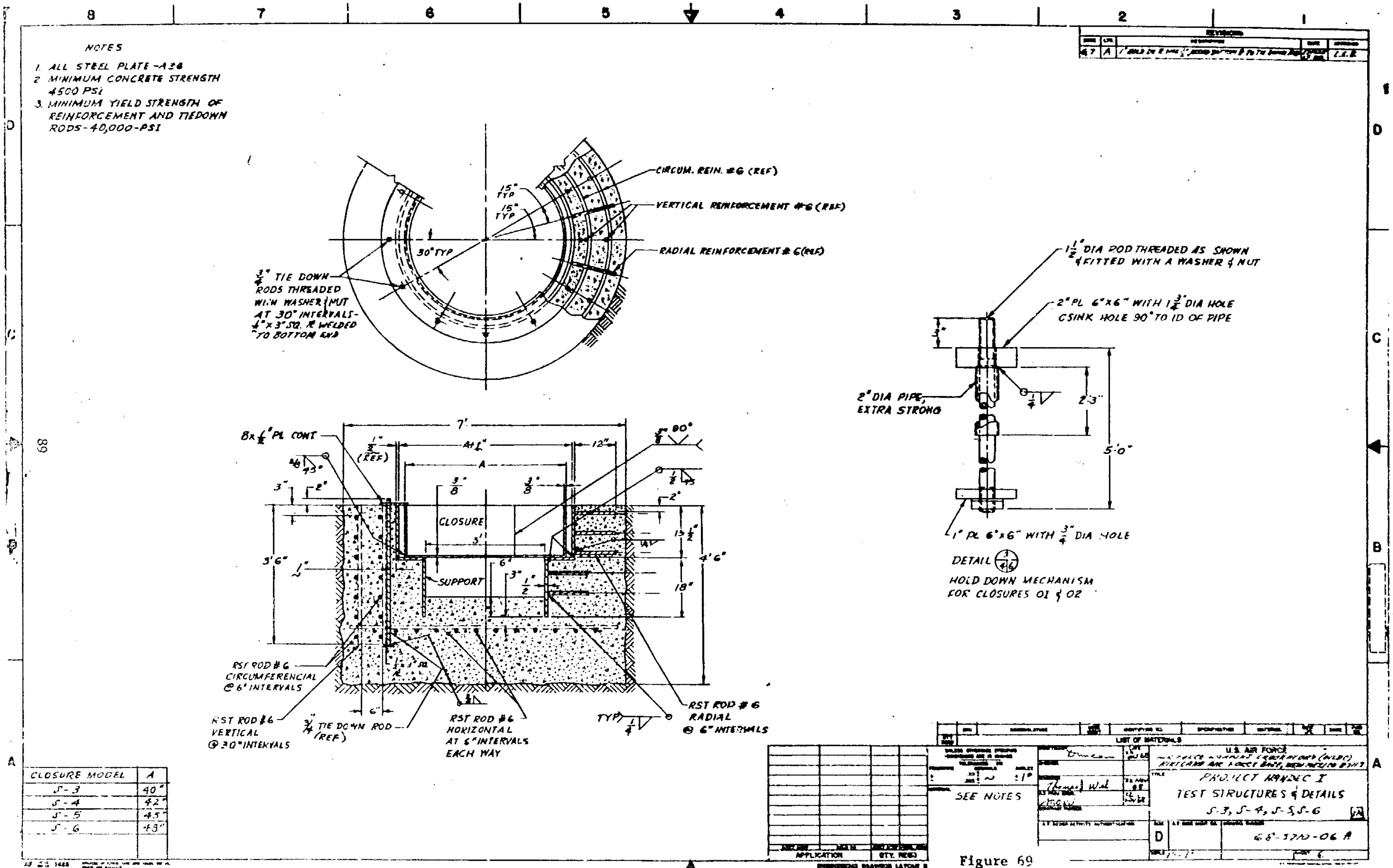
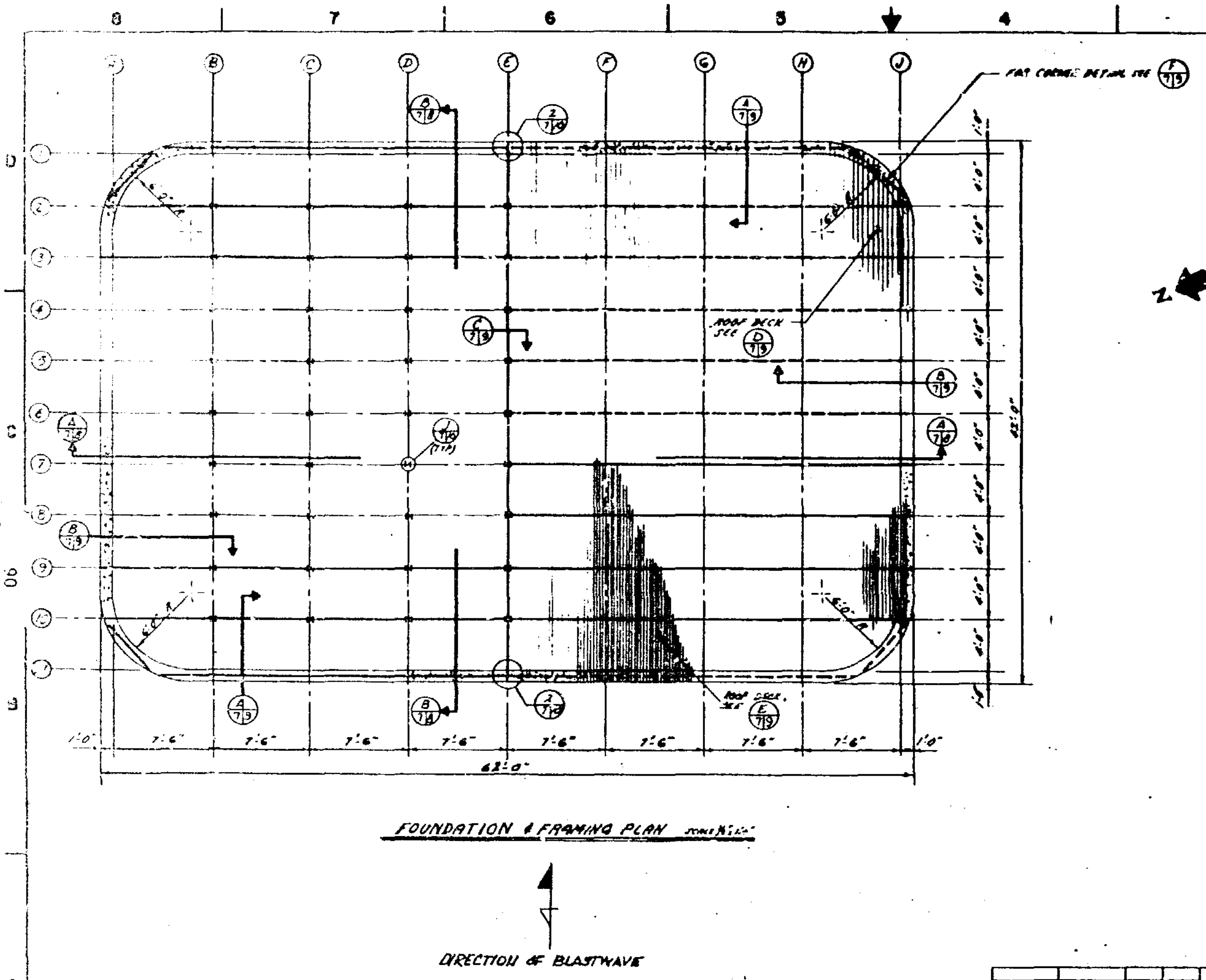

NOTES
1. ALL STEEL PLATE - A36
2. MINIMUM CONCRETE STRENGTH 4500 PSI
3. MINIMUM YIELD STRENGTH OF REINFORCEMENT AND TIEDOWN RODS - 40,000 - PSI
CIRCUM. REIN. #6 (REF)
VERTICAL REINFORCEMENT #6 (REF)
RADIAL REINFORCEMENT #6 (REF)
15° TYP
15° TYP
30° TYP
3/4" TIE DOWN RODS THREADED WITH WASHER & NUT AT 30° INTERVALS - 4"x3" SQ. PL WELDED TO BOTTOM END
8x1/4" PL CONT
7'
A+1"
12"
A
1/2" (REF)
CLOSURE
SUPPORT
3'
3'6"
4'6"
15 1/2"
18"
RST ROD #6 CIRCUMFERENCIAL @ 6" INTERVALS
RST ROD #6 VERTICAL @ 30" INTERVALS
3/4" TIE DOWN ROD (REF)
RST ROD #6 HORIZONTAL AT 6" INTERVALS EACH WAY
RST ROD #6 RADIAL @ 6" INTERVALS
TYP
1 1/2" DIA ROD THREADED AS SHOWN & FITTED WITH A WASHER & NUT
2" PL 6"x6" WITH 1 3/4" DIA HOLE CSINK HOLE 90° TO ID OF PIPE
2" DIA PIPE, EXTRA STRONG
2'3"
5'0"
1" PL 6"x6" WITH 3/4" DIA HOLE
DETAIL
HOLD DOWN MECHANISM FOR CLOSURES 01 & 02
CLOSURE MODEL | A
S-3 | 40"
S-4 | 42"
S-5 | 45"
S-6 | 43"
LIST OF MATERIALS
U.S. AIR FORCE
PROJECT HANDEC I
TEST STRUCTURES & DETAILS
S-3, S-4, S-5, S-6
SEE NOTES
APPLICATION
D
68-5710-06 A

Figure 69



GENERAL NOTES

1. BACKFILL AROUND CONCRETE WALLS TO BE BROUGHT UP APPROXIMATELY EVENLY ON ALL SIDES AFTER BEAMS AND ANGLE STRUTS ARE ERECTED.
2. ALLOWABLE SOIL PRESSURE - COLUMNS BEAR ON SOLID ROCK, ALLOWABLE BEARING = 10 KSI.
3. THE FIRST 5 FT. OF SURCHARGE ON THE STRUCTURE TO BE APPLIED WITH EQUIPMENT WEIGHING NOT MORE THAN 5000 LBS. THIS EQUIPMENT TO WORK ITS WAY ONTO THE DECK BY PROVIDING AN 18" CUSHION OF EARTH.
4. PROVIDE ADEQUATE DRAINAGE FOR THE STRUCTURE DURING ALL PHASES OF CONSTRUCTION.
5. CONCRETE - 3000 psi @ 28 DAYS UNLESS OTHERWISE NOTED
6. REINFORCING STEEL - INTERMEDIATE GRADE DEFORMED BARS ASTM A 15 & A 305.
7. SPLICES IN REINFORCING STEEL TO BE LAPPED 20 BAR DIAMETERS.
8. STEEL - ASTM A 36.
9. SHEET METAL - ASTM A 245 GRADE C (Fy = 33 ksi)
   ROOF DECK H-H ROBERTSON SEC 12-16
   SUB DECK - GRANCO HEAVY DUTY ([illegible]) CORRUFORM
10. BOLTS - ASTM A 307 (UNLESS NOTED OTHERWISE).
    HIGH STRENGTH (H.S.) BOLTS - ASTM A 325 FRICTION TYPE.
11. THE ENTIRE SPACE BETWEEN THE ROOF DECK AND SUB-DECK IS TO BE FILLED WITH EARTH @ 160 pcf.
12. ROOF DECK SHALL BE PROVIDED IN [illegible] OF 3-SPAN LENGTHS (12 FT.).

LIST OF MATERIALS

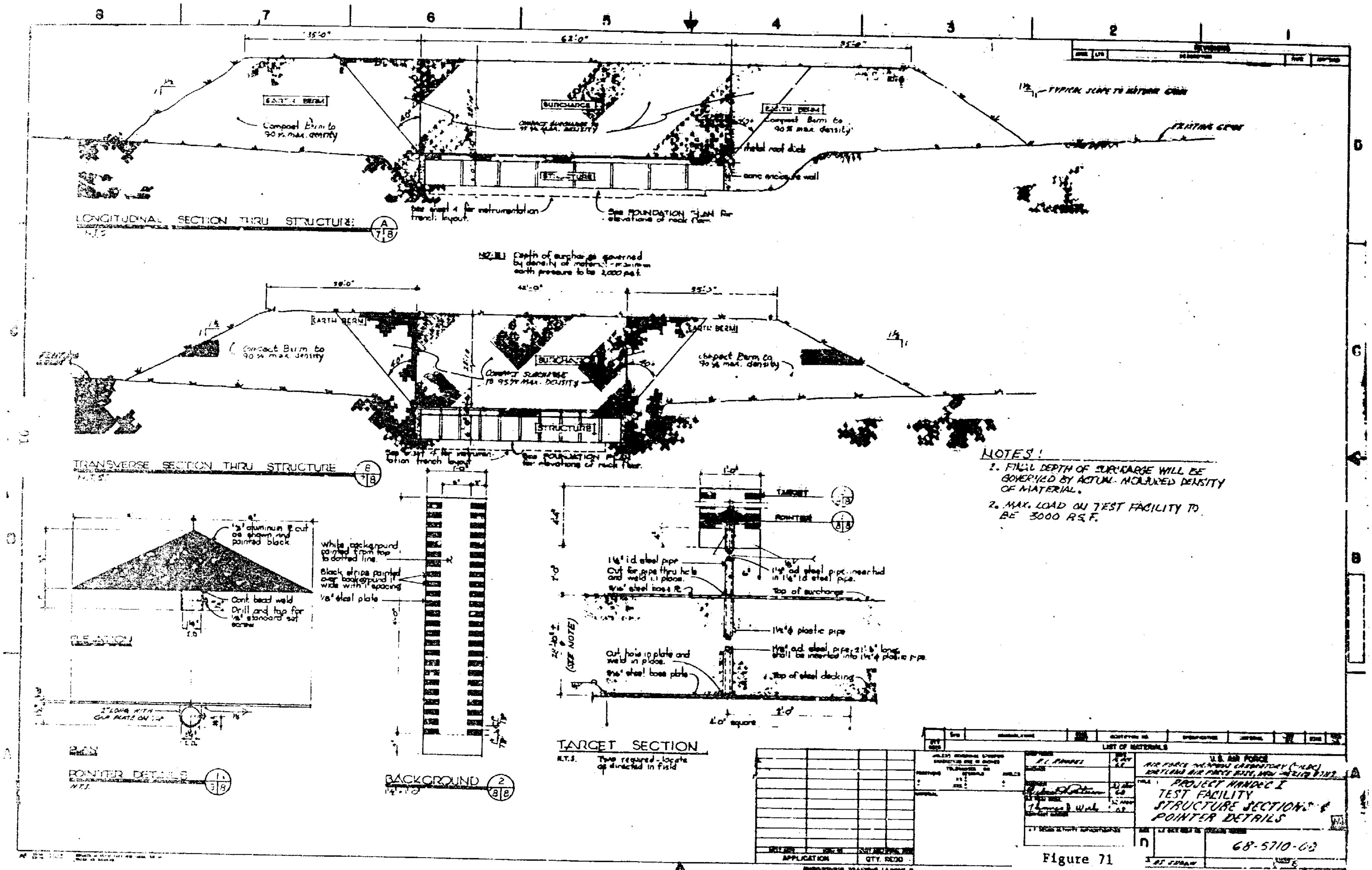
U.S. AIR FORCE

PROJECT HARDEC I
TEST FACILITY
FOUNDATION & FRAMING
PLAN

D

68-5710-07

Figure 70



LONGITUDINAL SECTION THRU STRUCTURE
EARTH BERM
Compact Berm to 90% max. density
SURCHARGE
STRUCTURE
See FOUNDATION PLAN for elevations of rock floor.
TRANSVERSE SECTION THRU STRUCTURE
NOTE: Depth of surcharge governed by density of material - maximum earth pressure to be 3,000 psf.
NOTES:
1. FINAL DEPTH OF SURCHARGE WILL BE GOVERNED BY ACTUAL MEASURED DENSITY OF MATERIAL.
2. MAX. LOAD ON TEST FACILITY TO BE 3000 P.S.F.
POINTER DETAILS
BACKGROUND
White background painted from top to dotted line.
Black strips painted over background 1" wide with 1" spacing
1/8" steel plate
TARGET SECTION
Two required - locate as directed in field
TARGET
POINTER
1 1/4" plastic pipe
Top of surcharge
Top of steel decking
U.S. AIR FORCE
AIR FORCE WEAPONS LABORATORY (WLDC)
KIRTLAND AIR FORCE BASE, NEW MEXICO 87117
PROJECT HANDEC I
TEST FACILITY
STRUCTURE SECTIONS & POINTER DETAILS
68-5710-03
APPLICATION
QTY. REQD
LIST OF MATERIALS

Figure 71

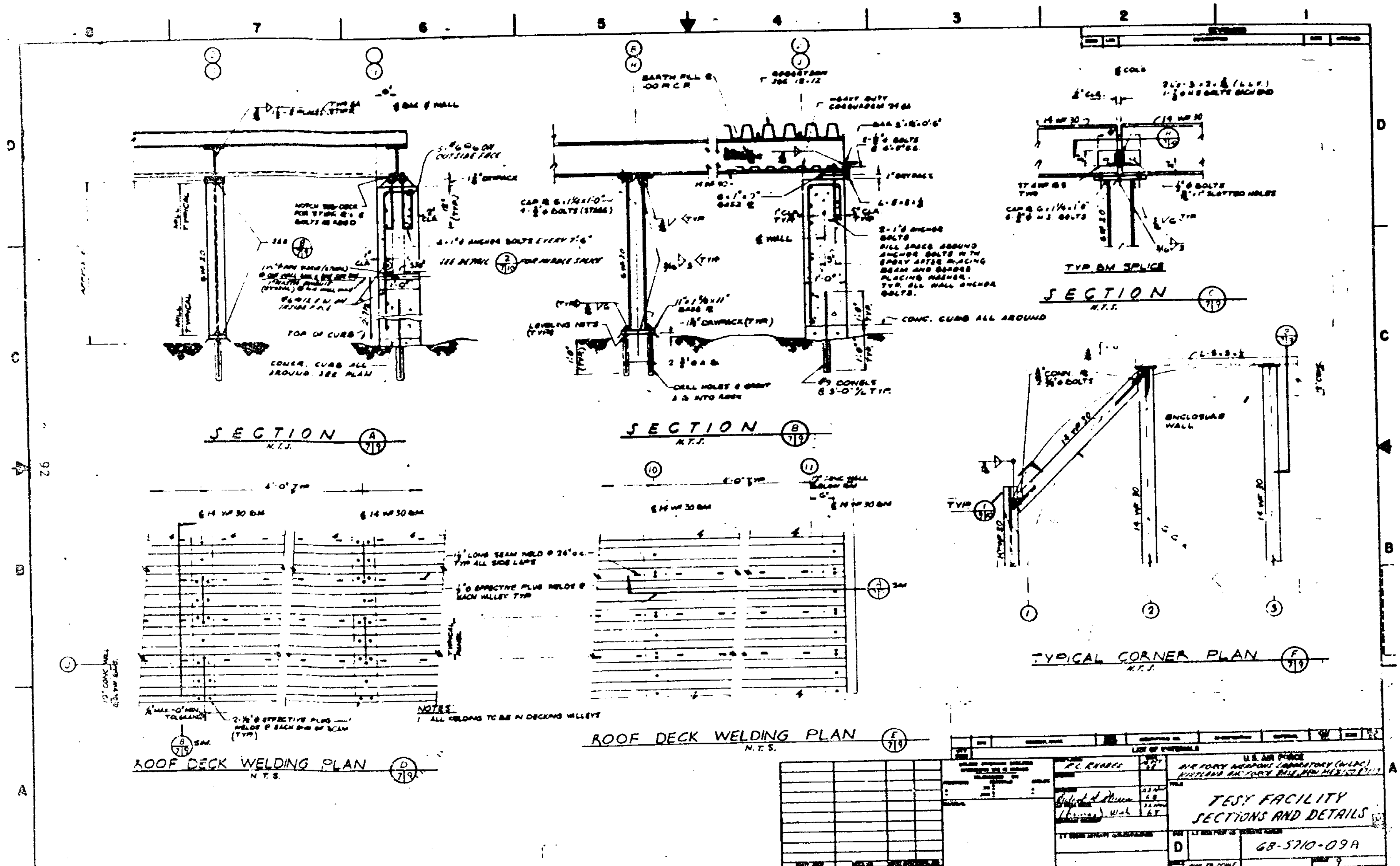

SECTION A 7/9
N.T.S.
SECTION B 7/9
N.T.S.
SECTION C 7/9
N.T.S.
TYP BM SPLICE
TYPICAL CORNER PLAN F 7/9
N.T.S.
ROOF DECK WELDING PLAN D 7/9
N.T.S.
ROOF DECK WELDING PLAN E 7/9
N.T.S.
ENCLOSURE WALL
CONC. CURB ALL AROUND
TOP OF CURB
NOTES:
1 ALL WELDING TO BE IN DECKING VALLEYS
U.S. AIR FORCE
AIR FORCE WEAPONS LABORATORY (WLDC)
KIRTLAND AIR FORCE BASE, NEW MEXICO 87117
TEST FACILITY
SECTIONS AND DETAILS
68-5710-09A

Figure 72

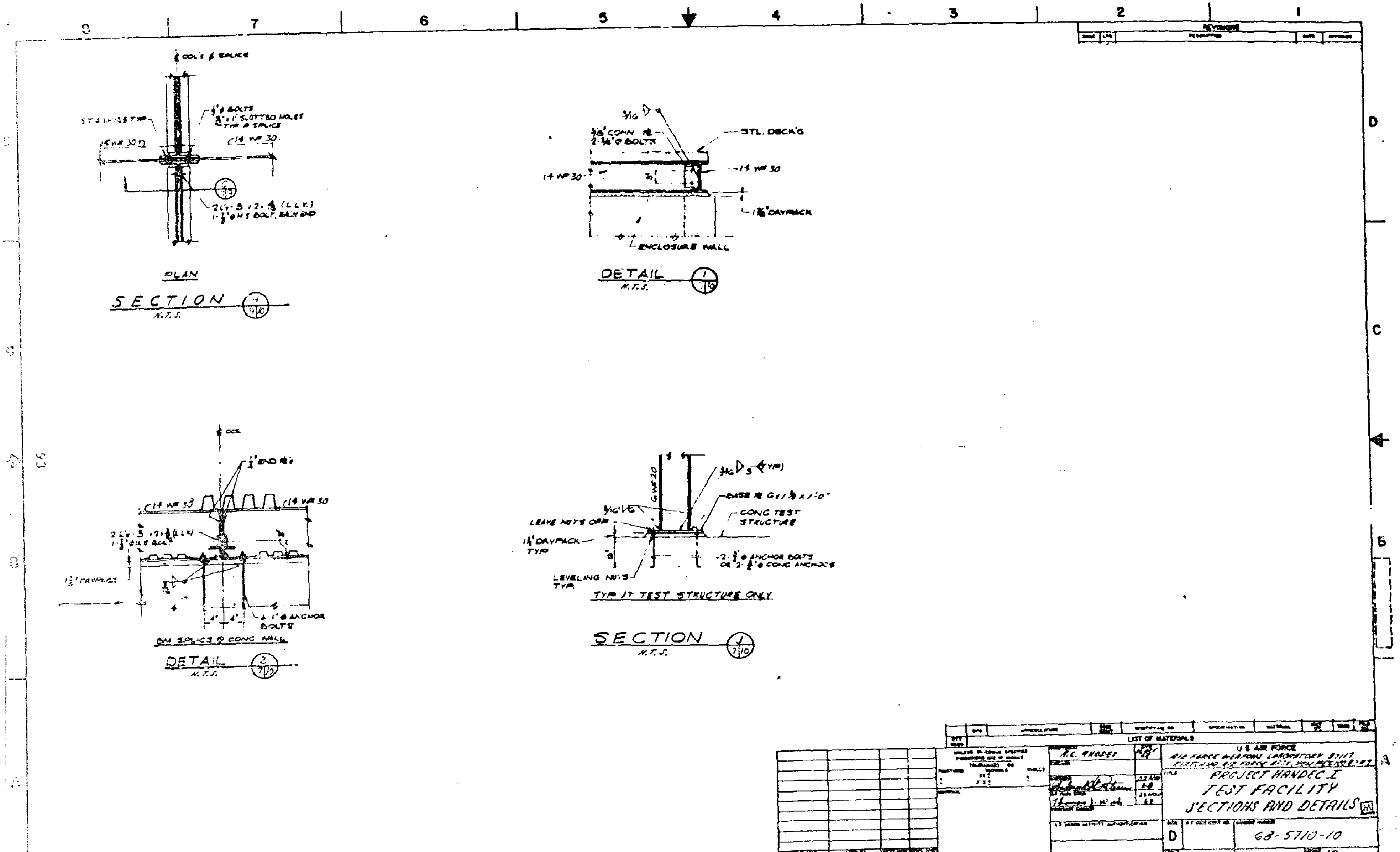

PLAN
SECTION
N.T.S.
DETAIL
N.T.S.
STL. DECK'G
14 WF 30
1⅝" DAYPACK
ENCLOSURE WALL
ON SPLICE @ CONC WALL
DETAIL
N.T.S.
LEAVE NUTS OFF
LEVELING NUTS TYP.
CONC TEST STRUCTURE
TYP AT TEST STRUCTURE ONLY
SECTION
N.T.S.
REVISIONS
LIST OF MATERIALS
U S AIR FORCE
PROJECT HANDEC I
TEST FACILITY
SECTIONS AND DETAILS
68-5710-10
APPLICATION
QTY. REQD

Figure 73

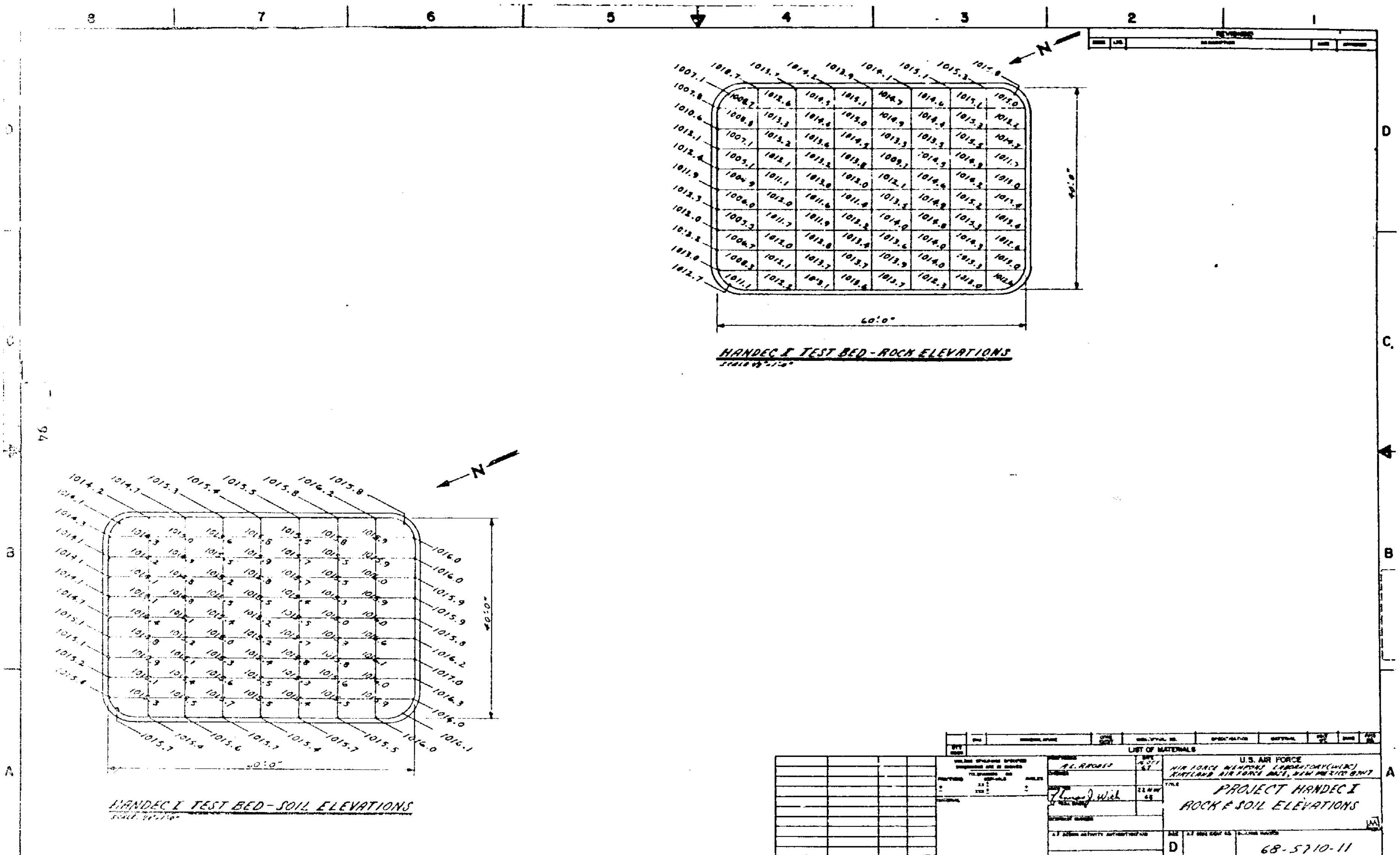

HANDEC I TEST BED - ROCK ELEVATIONS
HANDEC I TEST BED - SOIL ELEVATIONS
N
40'0"
60'0"
LIST OF MATERIALS
U.S. AIR FORCE
AIR FORCE WEAPONS LABORATORY (WLDC)
KIRTLAND AIR FORCE BASE, NEW MEXICO 87117
PROJECT HANDEC I
ROCK & SOIL ELEVATIONS
D
68-5710-11

Figure 74

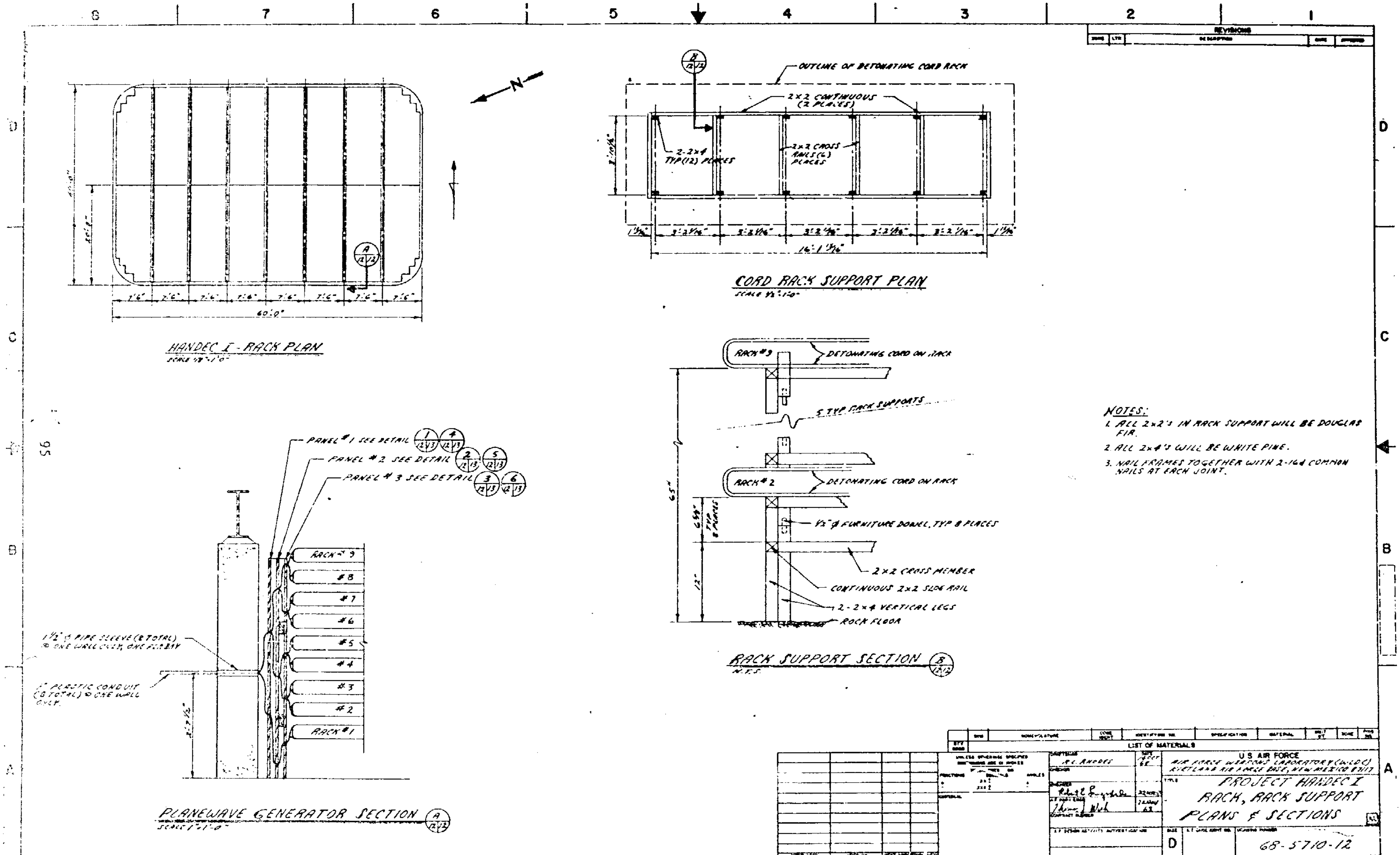

HANDEC I - RACK PLAN
60'-0"
CORD RACK SUPPORT PLAN
OUTLINE OF DETONATING CORD RACK
2×2 CONTINUOUS (2 PLACES)
2×2 CROSS RAILS (6) PLACES
2-2×4 TYP (12) PLACES
RACK SUPPORT SECTION
N.T.S.
DETONATING CORD ON RACK
5 TYP RACK SUPPORTS
1/2" ø FURNITURE DOWEL, TYP 8 PLACES
2×2 CROSS MEMBER
CONTINUOUS 2×2 SIDE RAIL
2-2×4 VERTICAL LEGS
ROCK FLOOR
RACK #9
RACK #2
65"
12"
PLANEWAVE GENERATOR SECTION
PANEL #1 SEE DETAIL
PANEL #2 SEE DETAIL
PANEL #3 SEE DETAIL
RACK #1
NOTES:
1. ALL 2×2'S IN RACK SUPPORT WILL BE DOUGLAS FIR.
2. ALL 2×4'S WILL BE WHITE PINE.
3. NAIL FRAMES TOGETHER WITH 2-16d COMMON NAILS AT EACH JOINT.
REVISIONS
LIST OF MATERIALS
U.S. AIR FORCE
AIR FORCE WEAPONS LABORATORY (WLDC)
KIRTLAND AIR FORCE BASE, NEW MEXICO 87117
PROJECT HANDEC I
RACK, RACK SUPPORT
PLANS & SECTIONS
68-5710-12
APPLICATION
QTY. REQD
ENGINEERING DRAWING LAYOUT B

Figure 75

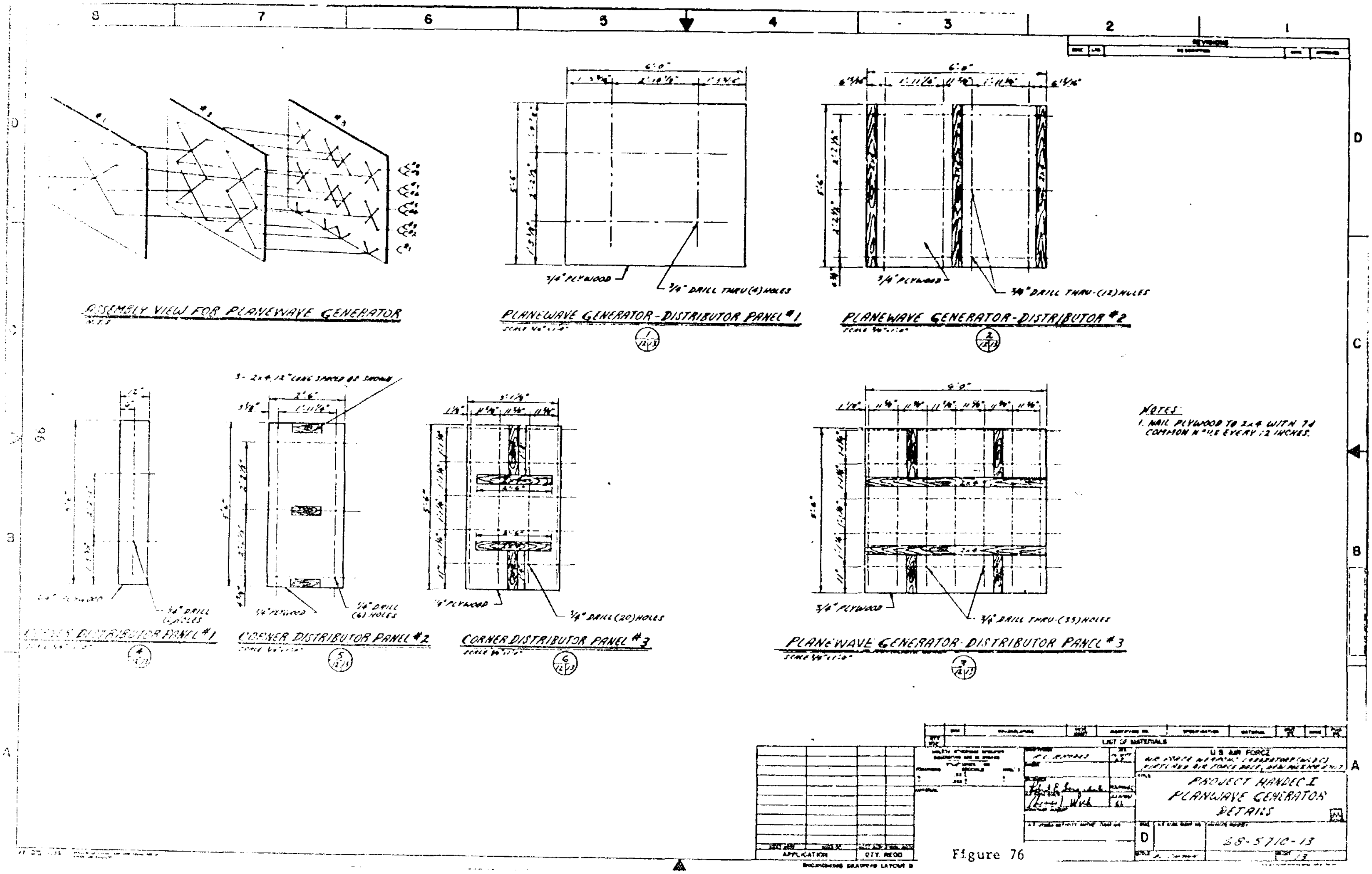

ASSEMBLY VIEW FOR PLANEWAVE GENERATOR
PLANEWAVE GENERATOR-DISTRIBUTOR PANEL #1
3/4" PLYWOOD
3/4" DRILL THRU (4) HOLES
PLANEWAVE GENERATOR-DISTRIBUTOR #2
3/4" DRILL THRU-(12) HOLES
NOTES:
1. NAIL PLYWOOD TO 2x4 WITH 7d COMMON NAILS EVERY 12 INCHES.
CORNER DISTRIBUTOR PANEL #1
CORNER DISTRIBUTOR PANEL #2
3-2x4, 12" LONG SPACED AS SHOWN
1/4" DRILL (6) HOLES
CORNER DISTRIBUTOR PANEL #3
3/4" DRILL (20) HOLES
PLANEWAVE GENERATOR-DISTRIBUTOR PANEL #3
3/4" DRILL THRU-(35) HOLES
U S AIR FORCE
PROJECT HANDEC I
PLANEWAVE GENERATOR
DETAILS
LIST OF MATERIALS
APPLICATION
QTY REQD
58-5710-13

Figure 76

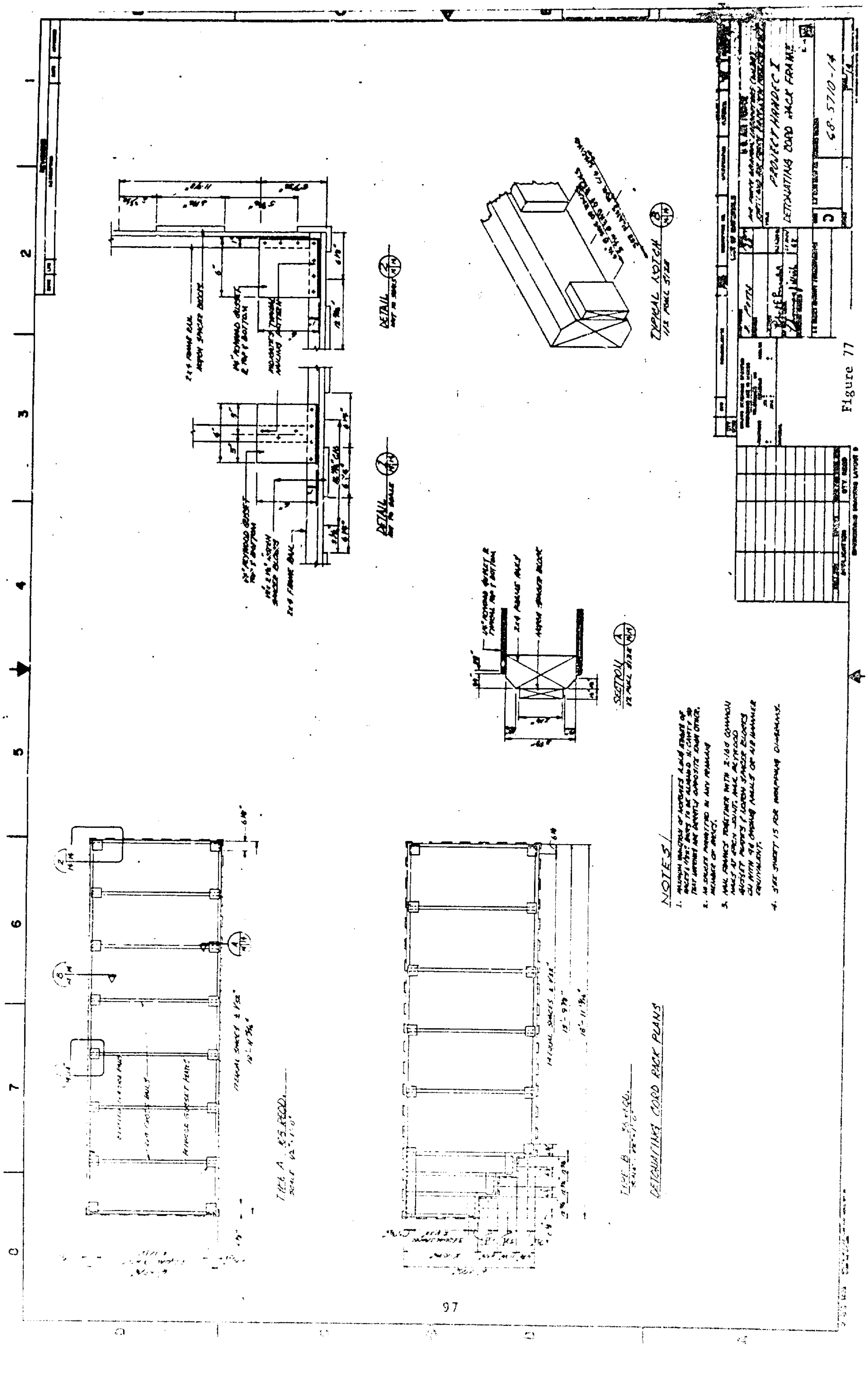

PROJECT HANDEC I
DETONATING CORD RACK FRAME
68-5710-14
NOTES
TYPICAL NOTCH
SECTION
DETAIL
DETONATING CORD RACK PLANS

Figure 77

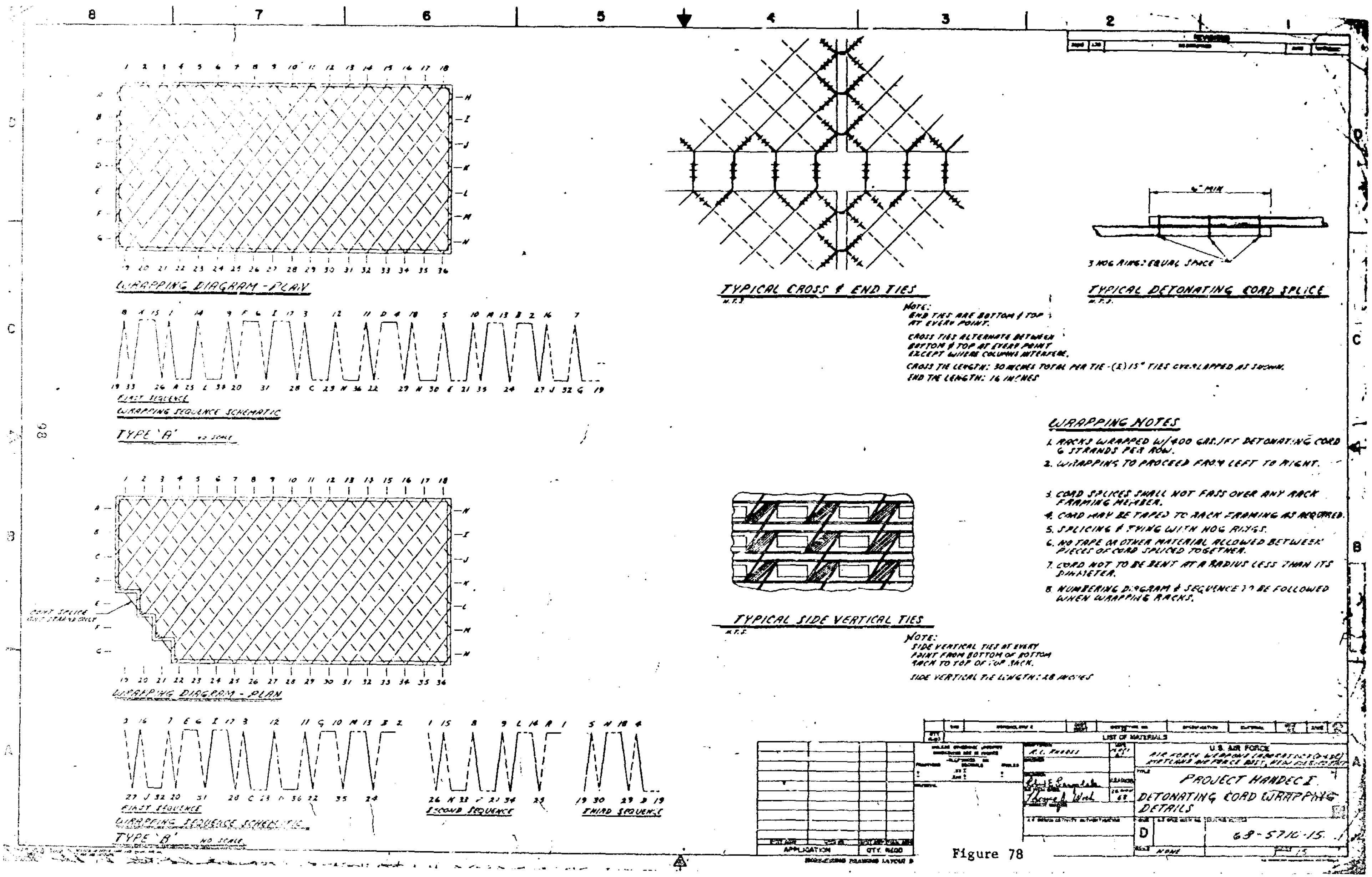
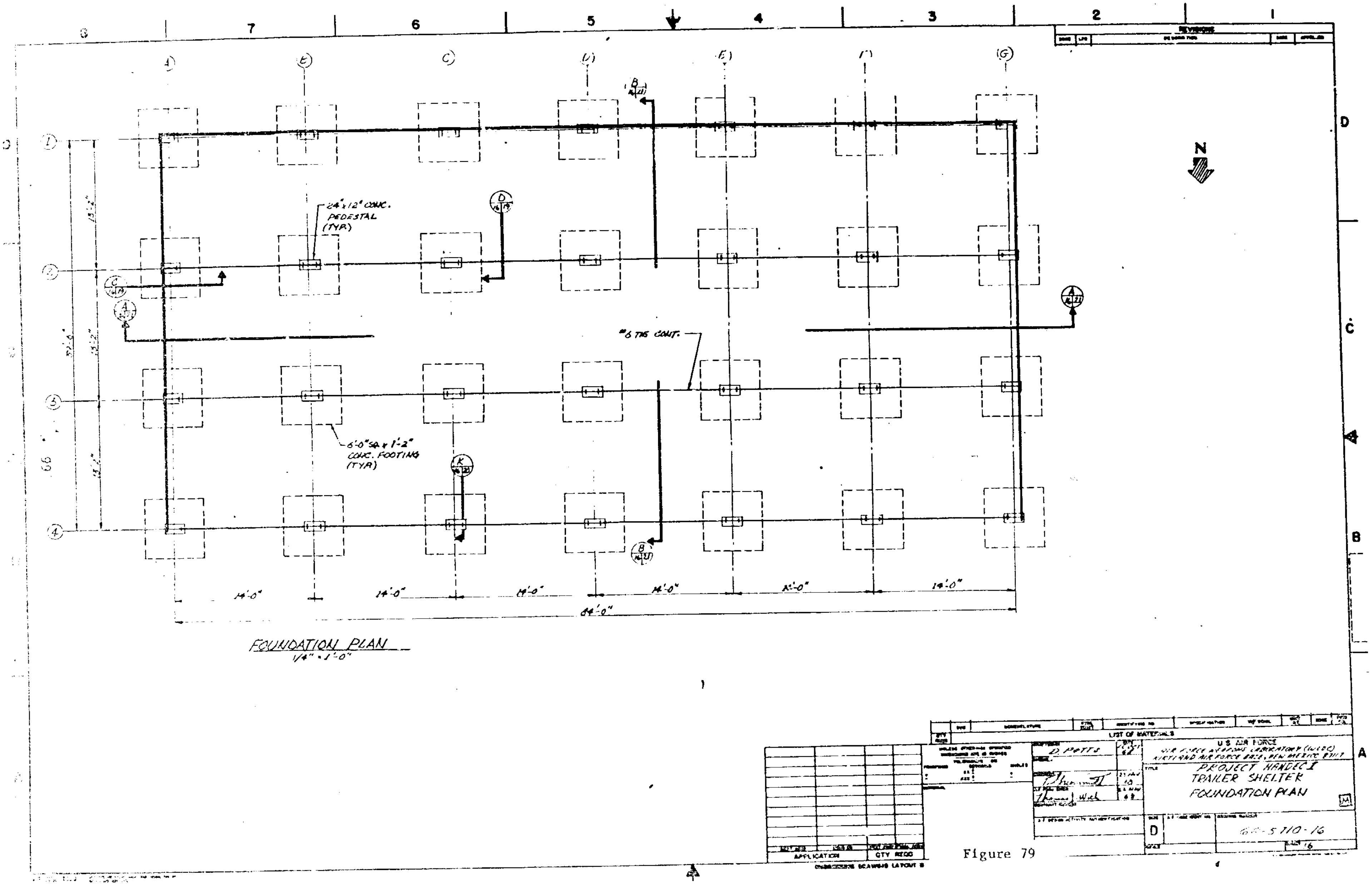
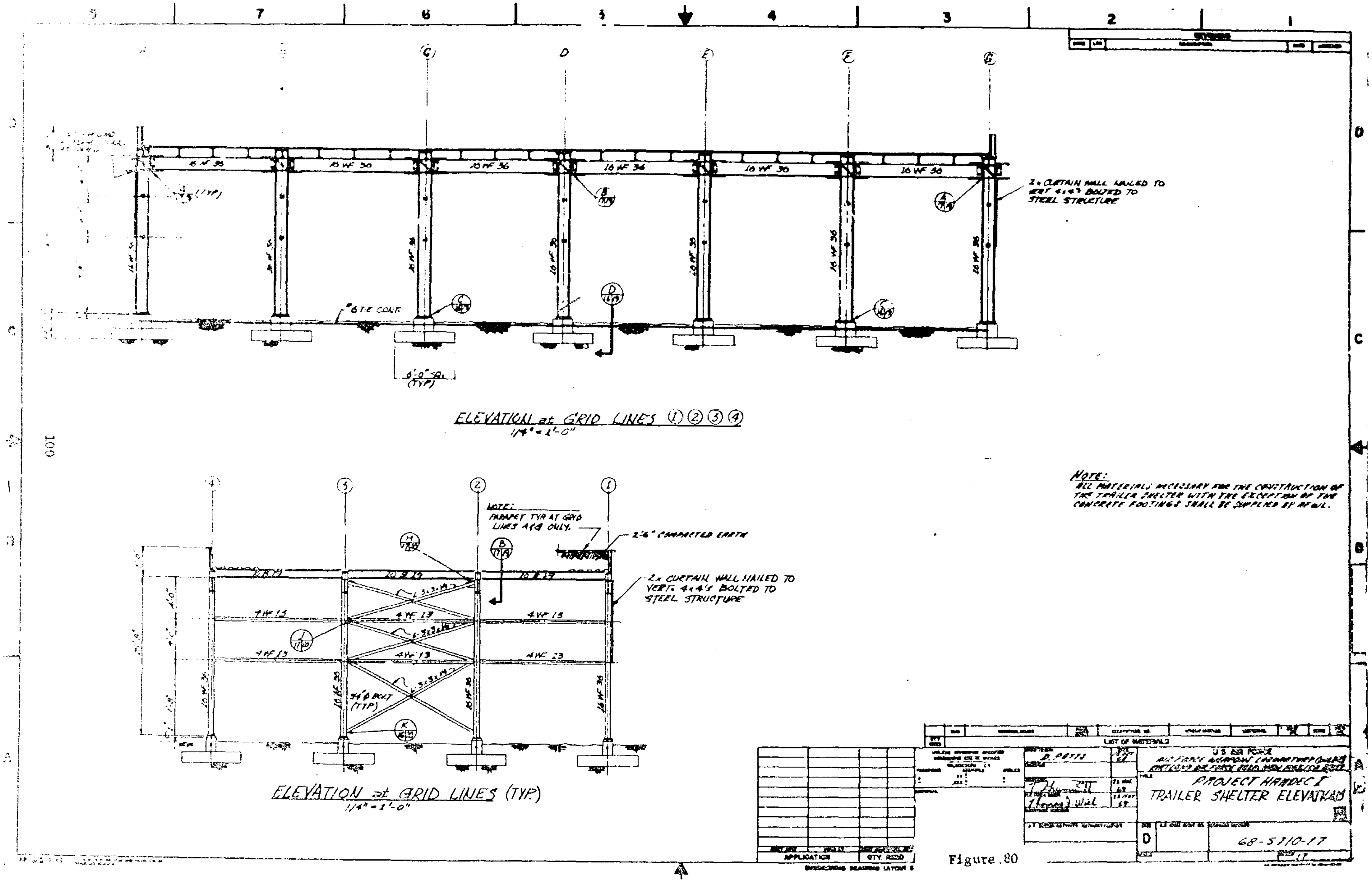

WRAPPING DIAGRAM - PLAN
FIRST SEQUENCE
WRAPPING SEQUENCE SCHEMATIC
TYPE 'A'
SECOND SEQUENCE
THIRD SEQUENCE
TYPE 'B' NO SCALE
TYPICAL CROSS & END TIES
NOTE:
END TIES ARE BOTTOM & TOP AT EVERY POINT.
CROSS TIES ALTERNATE BETWEEN BOTTOM & TOP AT EVERY POINT EXCEPT WHERE COLUMNS INTERFERE.
CROSS TIE LENGTH: 30 INCHES TOTAL PER TIE - (2) 15" TIES OVERLAPPED AS SHOWN.
END TIE LENGTH: 16 INCHES
3 HOG RINGS EQUAL SPACE
TYPICAL DETONATING CORD SPLICE
WRAPPING NOTES
1. RACKS WRAPPED W/400 GRS./FT DETONATING CORD 6 STRANDS PER ROW.
2. WRAPPINGS TO PROCEED FROM LEFT TO RIGHT.
3. CORD SPLICES SHALL NOT PASS OVER ANY RACK FRAMING MEMBER.
4. CORD MAY BE TAPED TO RACK FRAMING AS REQUIRED.
5. SPLICING & TYING WITH HOG RINGS.
6. NO TAPE OR OTHER MATERIAL ALLOWED BETWEEN PIECES OF CORD SPLICED TOGETHER.
7. CORD NOT TO BE BENT AT A RADIUS LESS THAN ITS DIAMETER.
8. NUMBERING DIAGRAM & SEQUENCE TO BE FOLLOWED WHEN WRAPPING RACKS.
TYPICAL SIDE VERTICAL TIES
NOTE:
SIDE VERTICAL TIES AT EVERY POINT FROM BOTTOM OF BOTTOM RACK TO TOP OF TOP RACK.
SIDE VERTICAL TIE LENGTH: 48 INCHES
U.S. AIR FORCE
PROJECT HANDEC I
DETONATING CORD WRAPPING DETAILS
D
69-5710-15
APPLICATION

Figure 78



24"x12" CONC. PEDESTAL (TYP.)
6'-0"SQ x 1'-2" CONC. FOOTING (TYP.)
#6 TIE CONT.
N
14'-0"
84'-0"
FOUNDATION PLAN
1/4" = 1'-0"
U.S. AIR FORCE
PROJECT HANDEC I
TRAILER SHELTER
FOUNDATION PLAN
D. POTTS
LIST OF MATERIALS
APPLICATION
QTY REQD

Figure 79



ELEVATION at GRID LINES ① ② ③ ④
1/4" = 1'-0"
2x CURTAIN WALL NAILED TO VERT 4x4's BOLTED TO STEEL STRUCTURE
16 WF 36
6'-0" SQ (TYP)
NOTE: ALL MATERIALS NECESSARY FOR THE CONSTRUCTION OF THE TRAILER SHELTER WITH THE EXCEPTION OF THE CONCRETE FOOTINGS SHALL BE SUPPLIED BY AFWL.
NOTE: PARAPET TYP AT GRID LINES 1 & 4 ONLY.
2'-6" COMPACTED EARTH
2x CURTAIN WALL NAILED TO VERT. 4x4's BOLTED TO STEEL STRUCTURE
4 WF 13
10 B 19
3/4" ϕ BOLT (TYP)
ELEVATION at GRID LINES (TYP.)
1/4" = 1'-0"
U.S. AIR FORCE
PROJECT HARDEC I
TRAILER SHELTER ELEVATION
D. PETTS
68-5710-17
APPLICATION
QTY. REQD

Figure 80

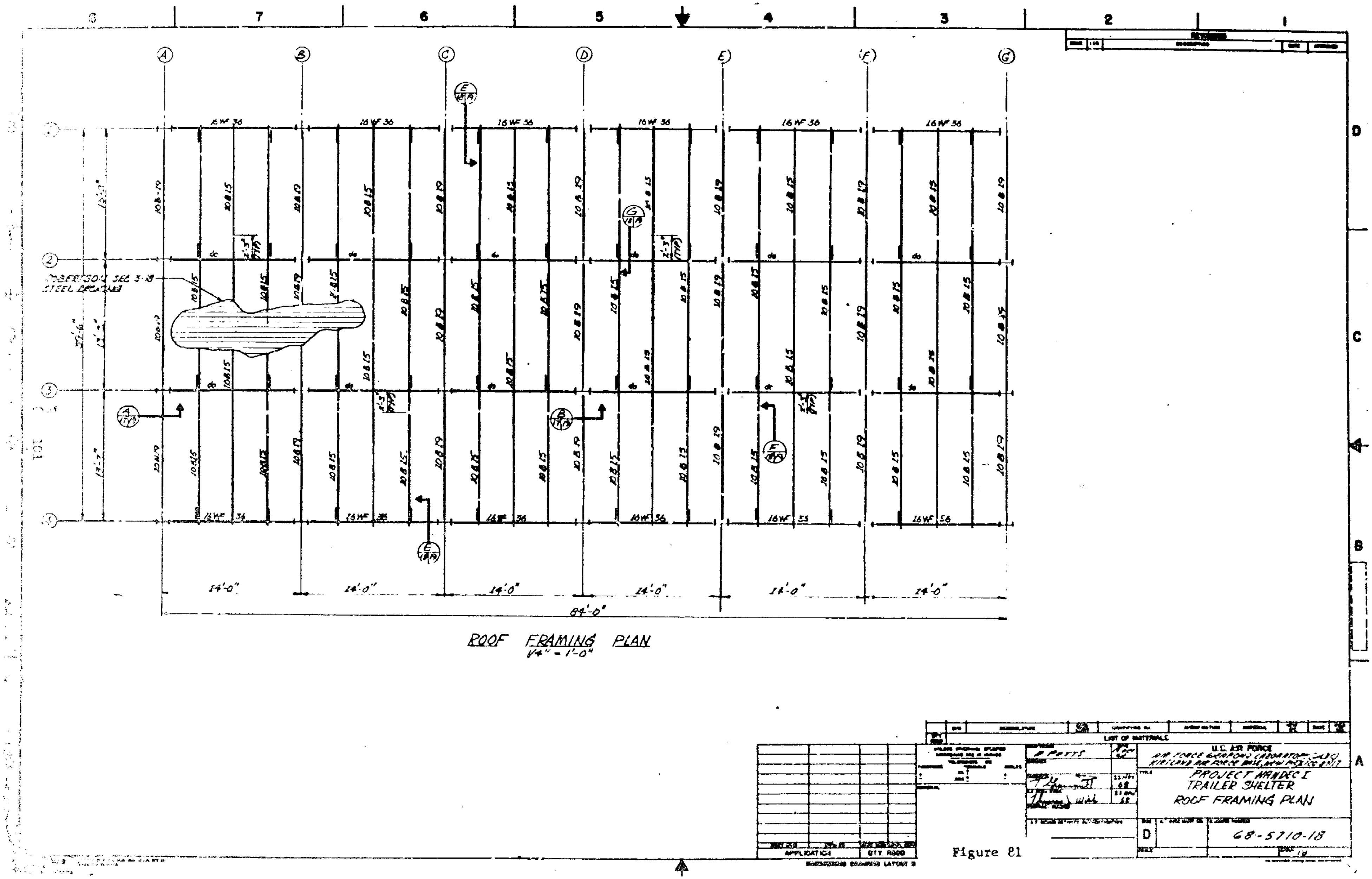

ROOF FRAMING PLAN
1/4" = 1'-0"
14'-0"
84'-0"
16 WF 36
10 B 15
10 B 19
ROBERTSON SEE 3-18 STEEL DRAWING
U.S. AIR FORCE
AIR FORCE WEAPONS LABORATORY (AFSC)
KIRTLAND AIR FORCE BASE, NEW MEXICO 87117
PROJECT MANDEC I
TRAILER SHELTER
ROOF FRAMING PLAN
LIST OF MATERIALS
APPLICATION
QTY. REQD
68-5710-18
D
B PETTS

Figure 81

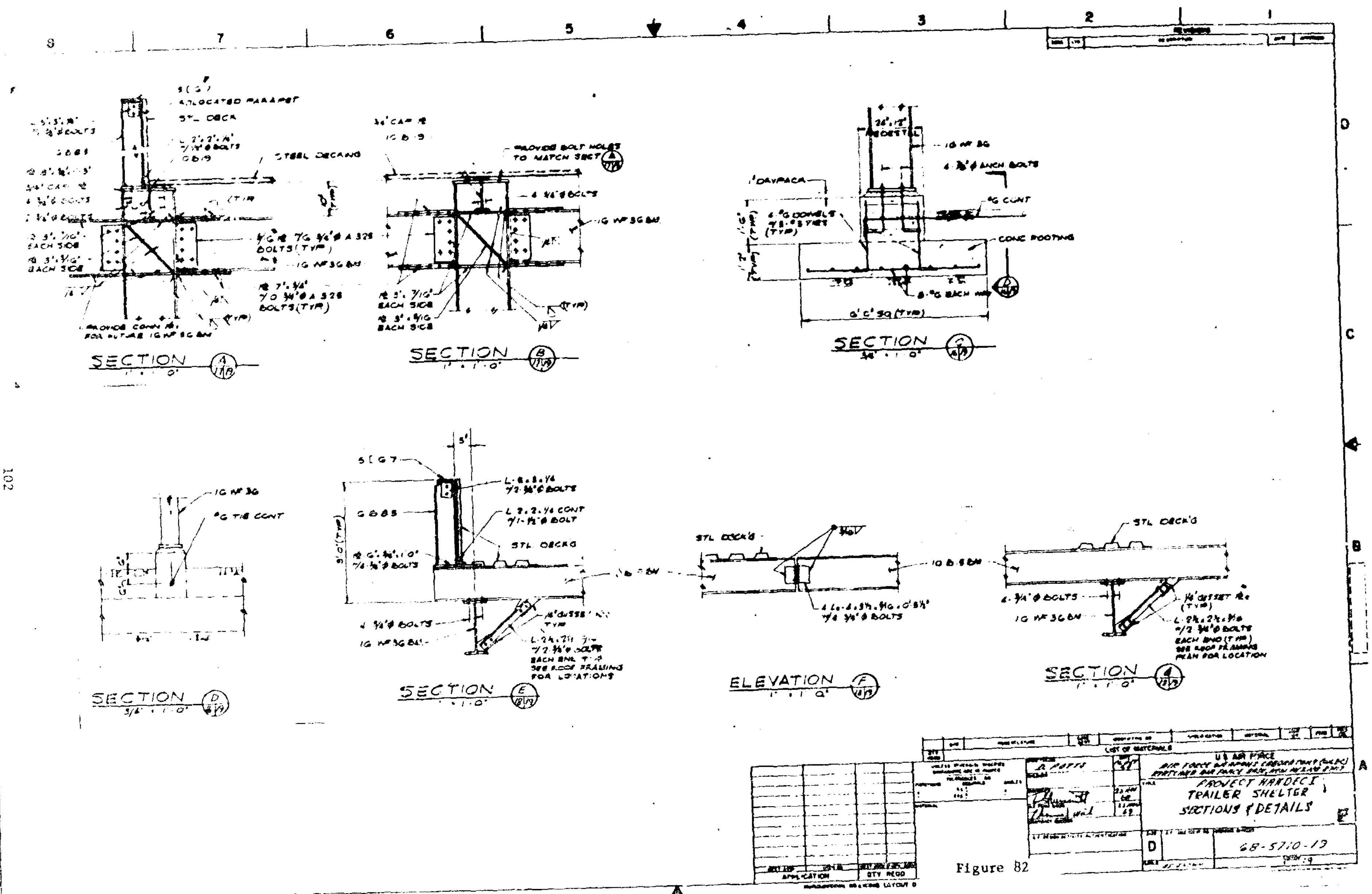
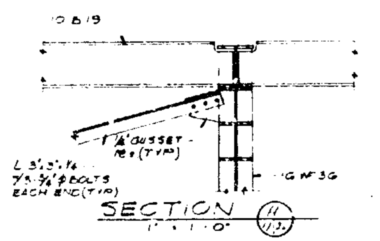
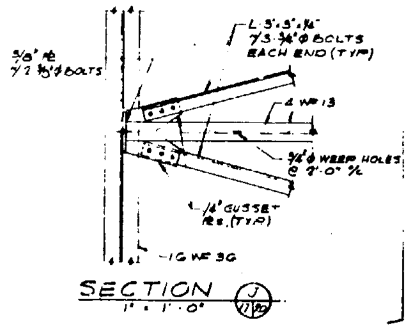
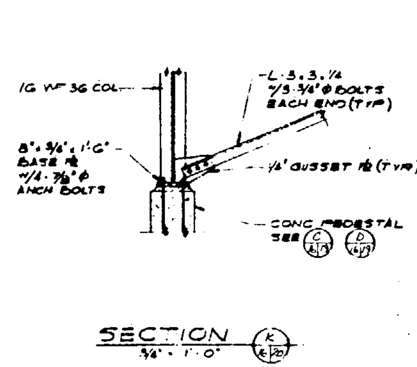

SECTION A
SECTION B
SECTION C
SECTION D
SECTION E
ELEVATION F
SECTION 4
STEEL DECKING
CONC FOOTING
STL DECK'G
U.S. AIR FORCE
PROJECT HARDEC I
TRAILER SHELTER
SECTIONS & DETAILS
68-5710-19

Figure 82







NOTES:

1. BOLTS SHALL BE ASTM A-307 UNLESS NOTED AS A-325 BOLTS. A-325 BOLTS SHALL HAVE THREADS EXCLUDED FROM SHEAR PLANES & SHALL BE TIGHTENED IN ACCORDANCE WITH A.I.S.C. SPECIFICATIONS FOR STRUCTURAL JOINTS USING ASTM A 325 BOLTS
2. ALL STRUCTURAL STEEL SHALL BE A-36
3. ALL WELDING SHALL BE WITH E-70 SERIES ELECTRODES
4. ALL CONCRETE SHALL HAVE A MINIMUM STRENGTH OF 3000 P.S.I. @ 28 DAYS. ALL REINFORCING SHALL BE A-15.
5. ASSUMED SAFE SOIL BEARING PRESS. - 3000 P.S.F.
6. METAL DECK - ROBERTSON SEC. 3-18

U.S. AIR FORCE
AIR FORCE WEAPONS LABORATORY (WLDC)
KIRTLAND AIR FORCE BASE, NEW MEXICO 87117

PROJECT HANDEC I
TRAILER SHELTER
SECTIONS & DETAILS

D 68-5710-20

SHEET 20

Figure 83

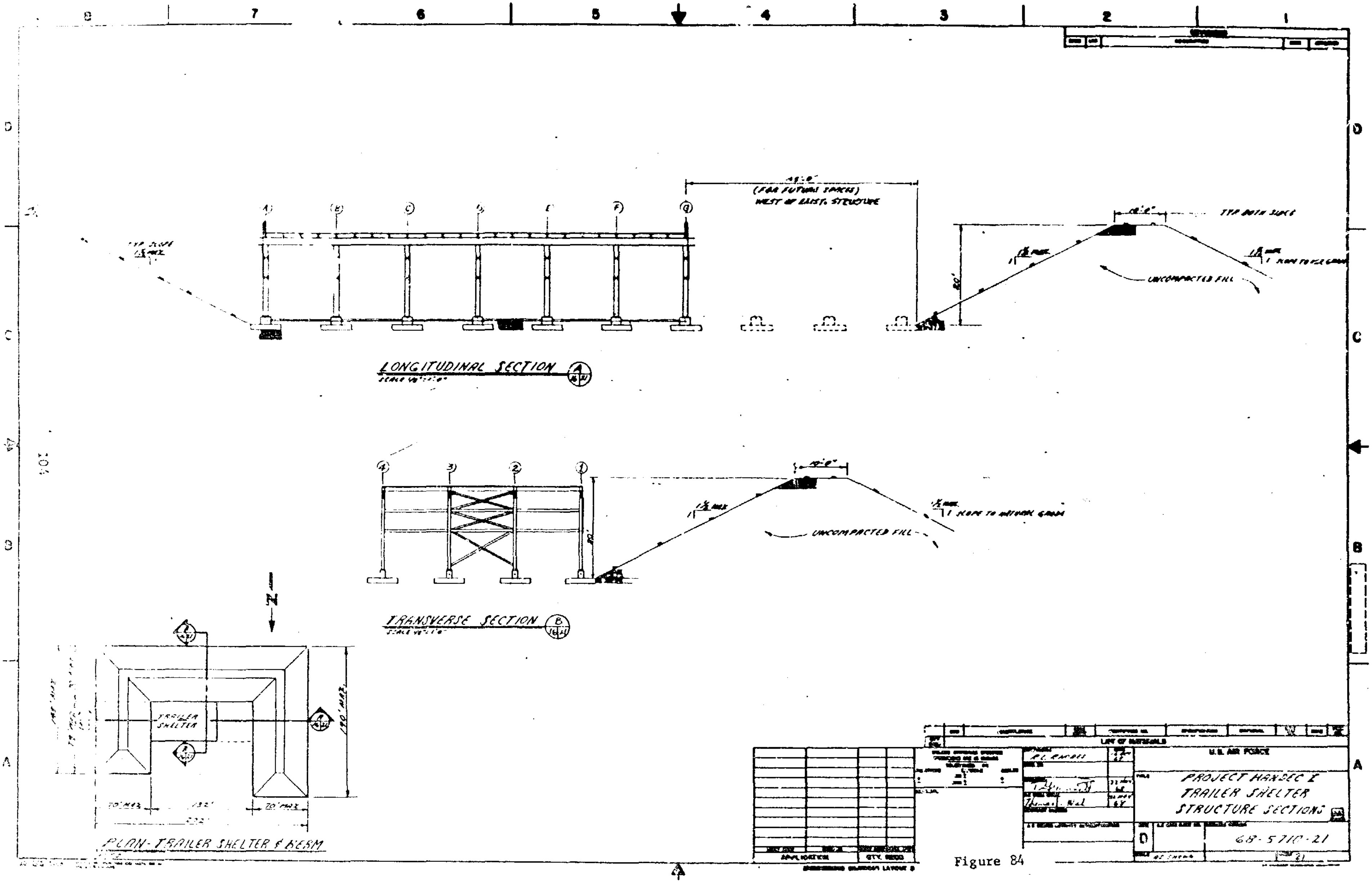

LONGITUDINAL SECTION
(FOR FUTURE SPACES)
WEST OF EXIST. STRUCTURE
TYP BOTH SIDES
UNCOMPACTED FILL
TRANSVERSE SECTION
UNCOMPACTED FILL
TRAILER SHELTER
PLAN-TRAILER SHELTER & BERM
U.S. AIR FORCE
PROJECT HARDEC I
TRAILER SHELTER
STRUCTURE SECTIONS
68-5710-21

Figure 84

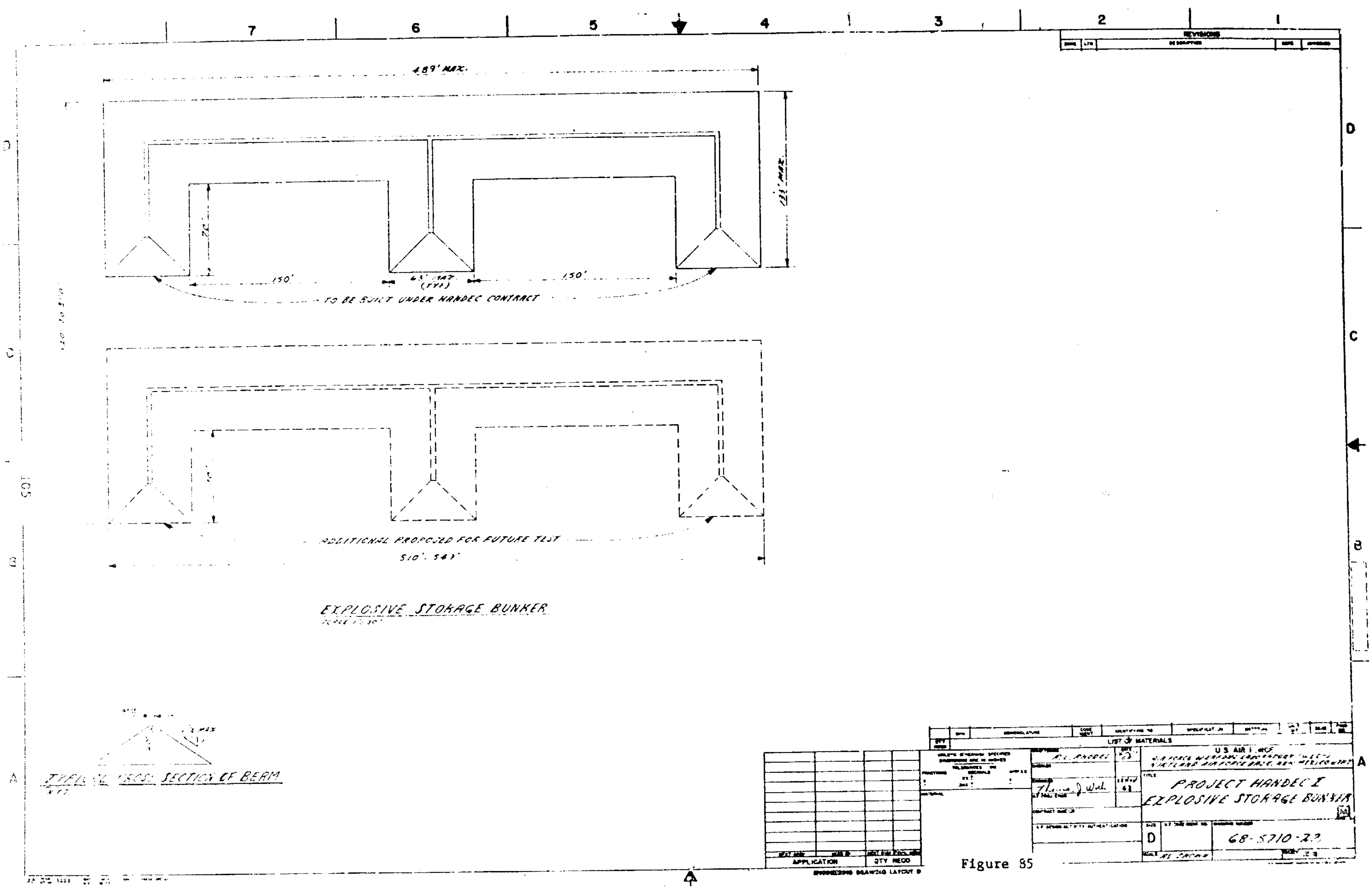
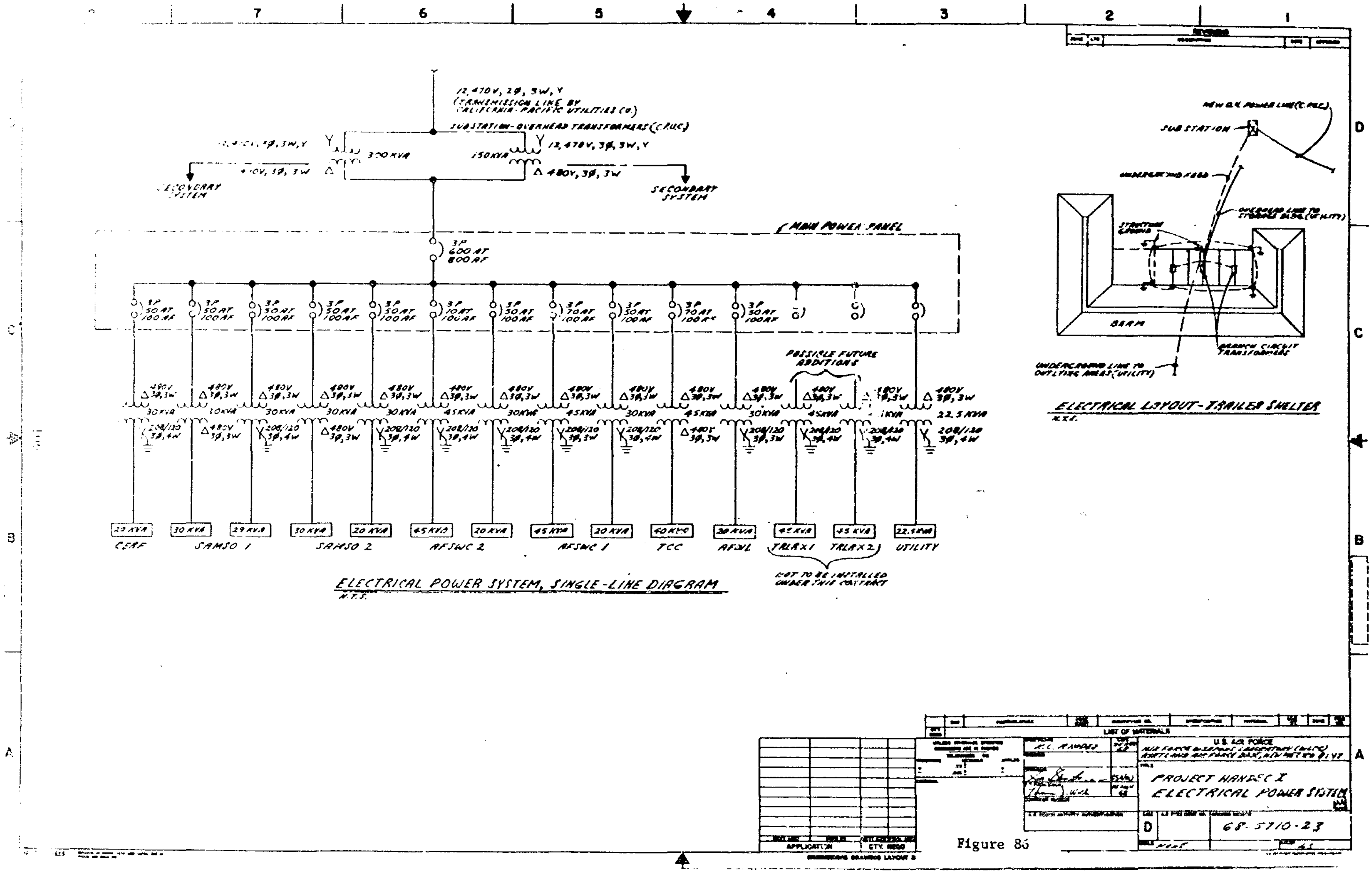

489' MAX.
123' MAX.
72'
150'
63' MAX. (TYP.)
150'
TO BE BUILT UNDER HANDEC CONTRACT
ADDITIONAL PROPOSED FOR FUTURE TEST
510' 547'
EXPLOSIVE STORAGE BUNKER
TYPICAL CROSS SECTION OF BERM
REVISIONS
LIST OF MATERIALS
U.S. AIR FORCE
PROJECT HANDEC I
EXPLOSIVE STORAGE BUNKER
D
68-5710-23
APPLICATION
QTY REQD

Figure 85



12,470V, 3Ø, 3W, Y
(TRANSMISSION LINE BY CALIFORNIA-PACIFIC UTILITIES CO)
SUBSTATION-OVERHEAD TRANSFORMERS (C.P.U.C.)
300 KVA
150KVA
12,470V, 3Ø, 3W, Y
480V, 3Ø, 3W
SECONDARY SYSTEM
MAIN POWER PANEL
3P 600 AT 800 AF
POSSIBLE FUTURE ADDITIONS
CERF
SAMSO 1
SAMSO 2
AFSWC 2
AFSWC 1
TCC
AFWL
TRLR X 1
TRLR X 2
UTILITY
NOT TO BE INSTALLED UNDER THIS CONTRACT
ELECTRICAL POWER SYSTEM, SINGLE-LINE DIAGRAM
N.T.S.
NEW O.H. POWER LINE (C.P.U.C.)
SUBSTATION
UNDERGROUND FEED
OVERHEAD LINE TO STORAGE BLDG. (UTILITY)
STRUCTURE GROUND
BERM
BRANCH CIRCUIT TRANSFORMERS
UNDERGROUND LINE TO OUTLYING AREAS (UTILITY)
ELECTRICAL LAYOUT-TRAILER SHELTER
N.T.S.
U.S. AIR FORCE
PROJECT HANDEC II
ELECTRICAL POWER SYSTEM
D
68-5710-23

Figure 86

APPENDIX IV

CONSTRUCTION DRAWINGS HANDEC II

This appendix contains the following drawings:

CONSTRUCTION DRAWINGS HANDEC II (cont'd)

PROJECT HANDEC II

CEDAR CITY TEST SITE

AIR FORCE WEAPONS LABORATORY (WLDC)
DEVELOPMENT DIVISION, CIVIL ENGINEERING BRANCH
KIRTLAND AIR FORCE BASE, NEW MEXICO 87117

INDEX OF DRAWINGS

S-1	TEST FACILITY - VICINITY MAP, SITE LOCATION MAP AND EXISTING SOIL, ROCK ELEVATIONS	E-1	SYMBOLS AND GENERAL NOTES
S-2	TEST FACILITY - GENERAL NOTES, FOUNDATION AND FRAMING PLAN	E-2	GENERAL SITE PLAN
S-3	TEST FACILITY - CROSS SECTIONS	E-3	SINGLE LINE DIAGRAMS
[illegible]	TEST FACILITY - SECTIONS AND DETAILS	E-4	TRAILER AREA POWER PLAN AND DETAILS
[illegible]	TEST FACILITY - SECTIONS AND DETAILS	E-5	PRE-FAB BUILDING PLAN AND DETAILS
[illegible]	TEST FACILITY - DETONATING FUSE, RACK FRAMING PLANS, SECTIONS AND DETAILS	E-6	LIGHTNING PROTECTION PLANS AND DETAILS
[illegible]	TEST FACILITY - DETONATING CORD WRAPPING, NOTES, PLANS AND DETAILS		
[illegible]	TEST FACILITY - TRENCH EXCAVATING PLAN		
S-8	CLOSURES 11 THRU 15, LINED AND LINED BACKPACKED SILOS, SECTIONS AND DETAILS		
S-9	CLOSURES 16 THRU 19, GENERAL NOTES, PLAN, SECTIONS AND DETAILS		
[illegible]	PRE-FAB STRUCTURE, FOUNDATION PLAN, SECTIONS AND DETAILS		
[illegible]	EARTH BERM, PLAN AND SECTIONS		

Figure 87

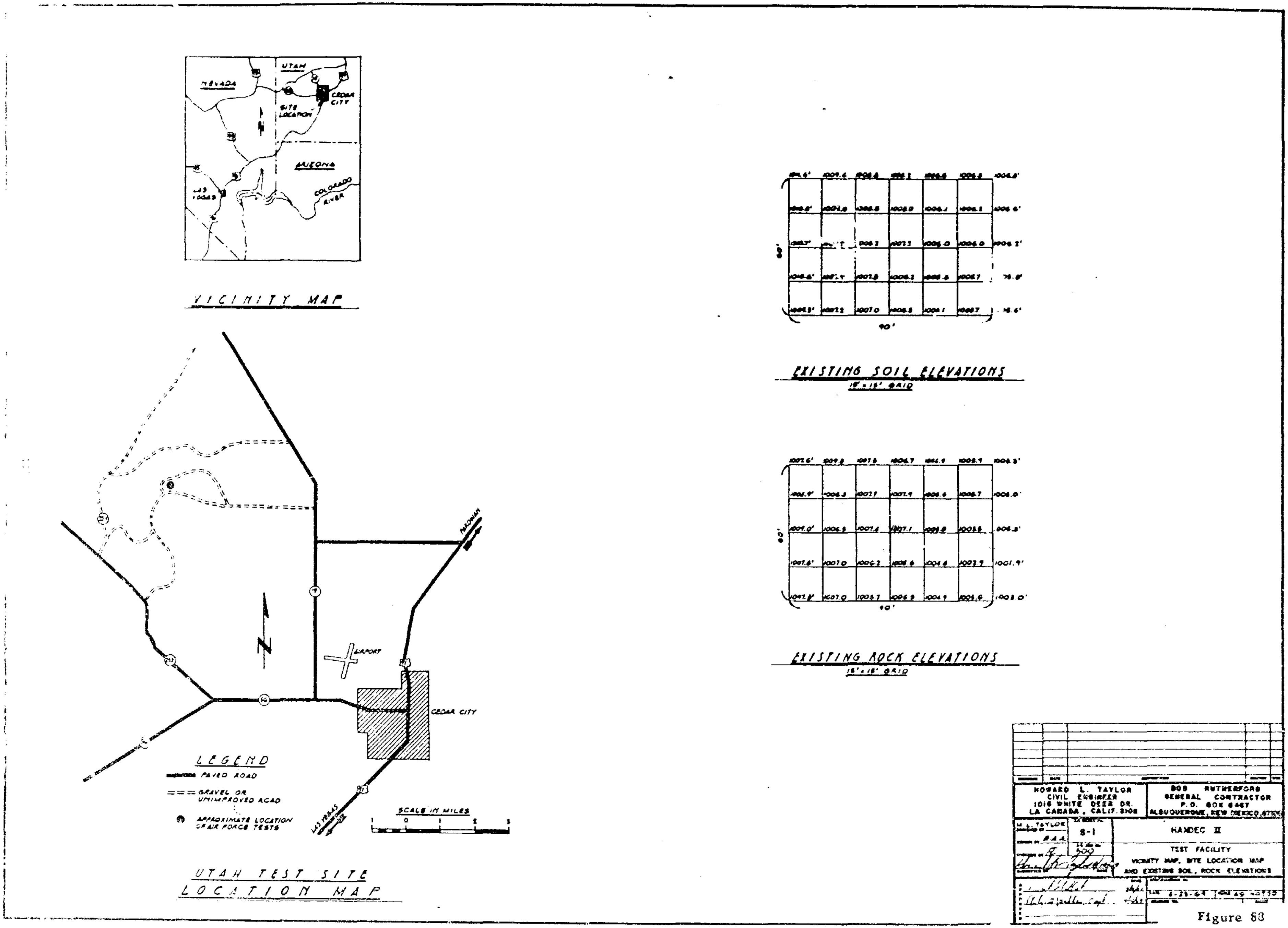
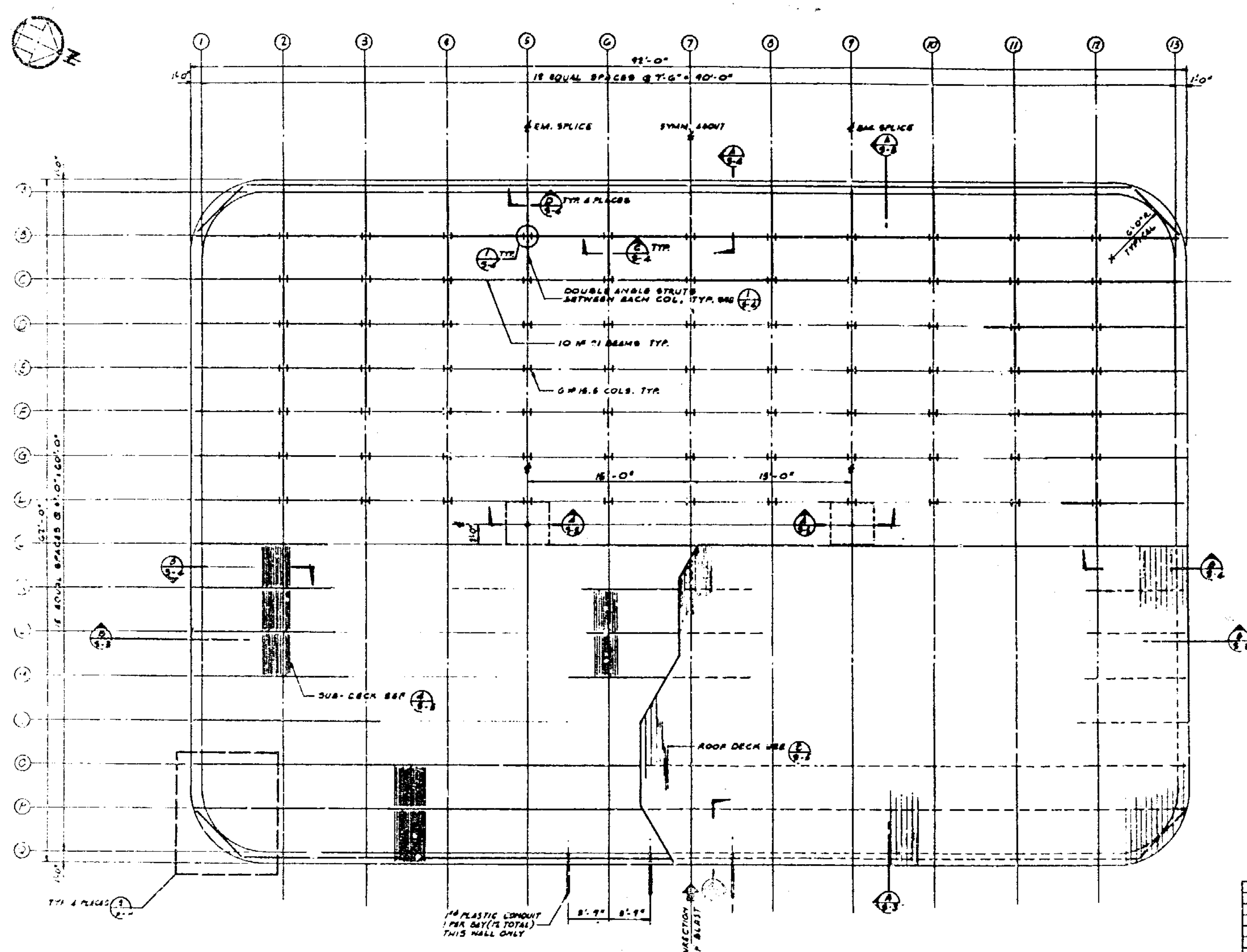

UTAH
NEVADA
ARIZONA
CEDAR CITY
SITE LOCATION
LAS VEGAS
COLORADO RIVER
VICINITY MAP
EXISTING SOIL ELEVATIONS
15' x 15' GRID
EXISTING ROCK ELEVATIONS
15' x 15' GRID
90'
60'
AIRPORT
CEDAR CITY
LAS VEGAS
LEGEND
PAVED ROAD
GRAVEL OR UNIMPROVED ROAD
APPROXIMATE LOCATION OF AIR FORCE TESTS
SCALE IN MILES
UTAH TEST SITE
LOCATION MAP
HOWARD L. TAYLOR
CIVIL ENGINEER
1016 WHITE DEER DR.
LA CANADA, CALIF.
BOB RUTHERFORD
GENERAL CONTRACTOR
P.O. BOX 8467
ALBUQUERQUE, NEW MEXICO
HANDEC II
TEST FACILITY
VICINITY MAP, SITE LOCATION MAP
AND EXISTING SOIL, ROCK ELEVATIONS
S-1

Figure 83



FOUNDATION & FRAMING PLAN

1/4" = 1'-0"

GENERAL NOTES

1. BACKFILL AROUND CONCRETE WALLS TO BE BROUGHT UP APPROXIMATELY EVENLY ON ALL SIDES AFTER BEAMS AND ANGLE STRUTS ARE ERECTED.
2. ALLOWABLE SOIL PRESSURE - COLUMNS BEAR ON SOLID ROCK, ALLOWABLE BEARING =
3. THE FIRST 8 FT. OF SURCHARGE ON THE STRUCTURE TO BE APPLIED WITH EQUIPMENT WEIGHING NOT MORE THAN 8000 LBS. THIS EQUIPMENT TO WORK ITS WAY ONTO THE DECK BY PROVIDING AN 18" CUSHION OF EARTH.
4. PROVIDE ADEQUATE DRAINAGE FOR THE STRUCTURE DURING ALL PHASES OF CONSTRUCTION.
5. CONCRETE = 3000 P.S.I. @ 28 DAYS UNLESS OTHERWISE NOTED.
6. REINFORCING STEEL - INTERMEDIATE GRADE DEFORMED BARS A.S.T.M. A15 AND A 305.
7. SPLICES IN REINFORCING STEEL TO BE LAPPED 30 BAR DIAMETERS.
8. STEEL - A.S.T.M. A 36
9. BOLTS A.S.T.M. A 307 (UNLESS NOTED OTHERWISE) HIGH STRENGTH (H.S) BOLTS A.S.T.M. A 325 FRICTION TYPE.
10. ROOF DECKING TO BE H.H. ROBERTSON CO. SECTION 12. MATERIAL TO BE IN ACCORDANCE WITH A.S.T.M. A245, GRADE E (Fy = 80 KSI) 16 GAGE, 4½" DEEP WITH FOUR WEBS PER FOOT. WEIGHT TO BE 7.5#/□ AND SECTION MODULUS = 2.39 in³
11. ROOF DECK SHALL BE PROVIDED IN MINIMUM OF 3 SPAN LENGTHS (20 FT.)
12. SUB-DECK SHALL BE GRANCO 24 GAGE TUFCOR. WEIGHT (UNCOATED) PER COVER WIDTH = 1.25#/□ SECTION MODULUS PER FOOT WIDTH = 0.131 in³
13. THE ENTIRE SPACE BETWEEN THE ROOF DECK AND SUB-DECK IS TO BE FILLED WITH EARTH @ 100 PCF.
14. EACH COLUMN LENGTH WILL BE DETERMINED BY ACTUAL FIELD SURVEY.
15. FOR LEGEND SEE SHEET S-3.

HOWARD L. TAYLOR CIVIL ENGINEER 1016 WHITE DEER DR LA CANADA, CALIF. 91011	BOB RUTHERFORD GENERAL CONTRACTOR P O BOX 8467 ALBUQUERQUE, NEW MEXICO, 87108
H. TAYLOR / R.A.A. / S-2 / 300	HANDEC II TEST FACILITY GENERAL NOTES FOUNDATION AND FRAMING PLAN
DATE 4-25-64	NOTED

Figure 89

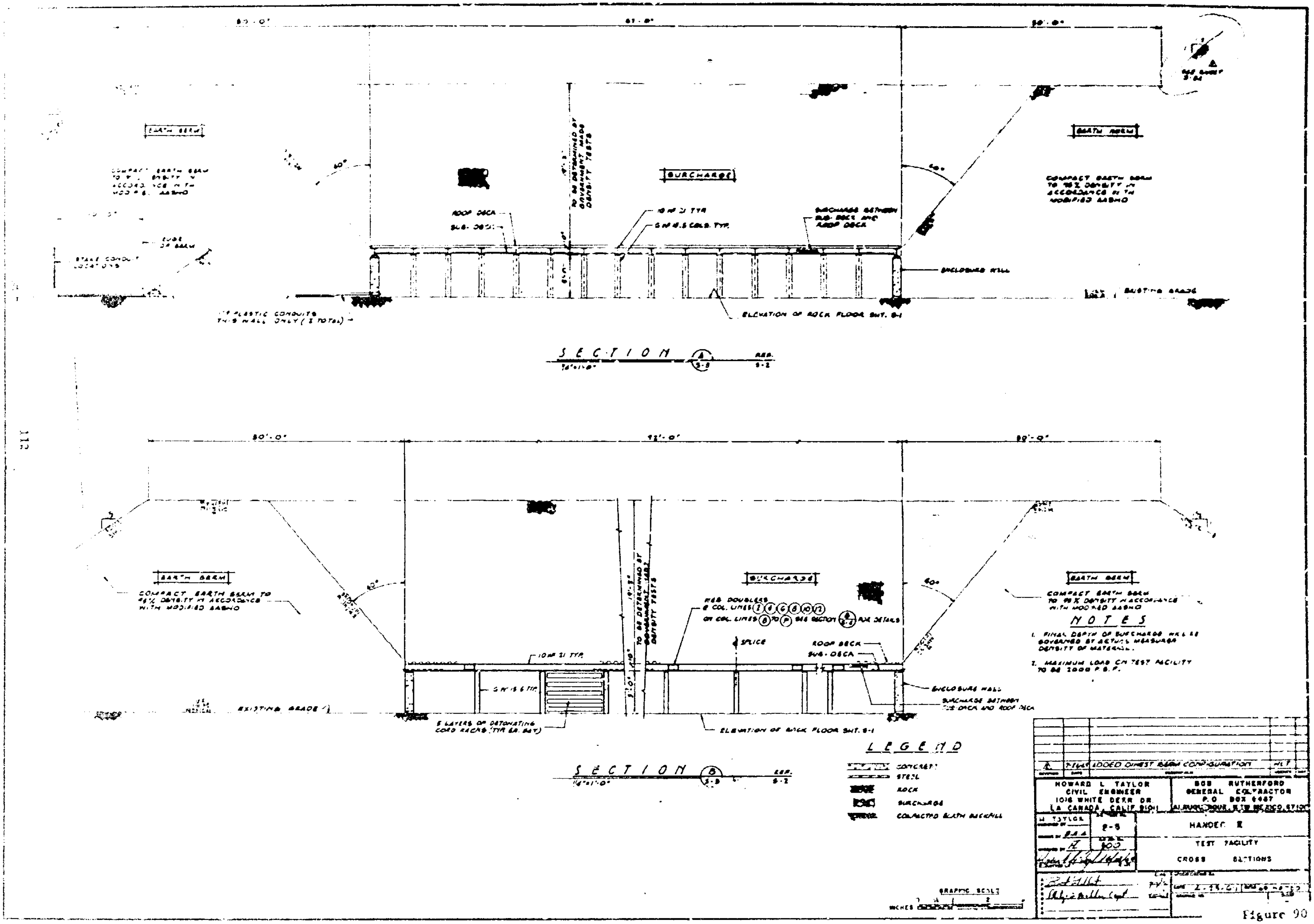
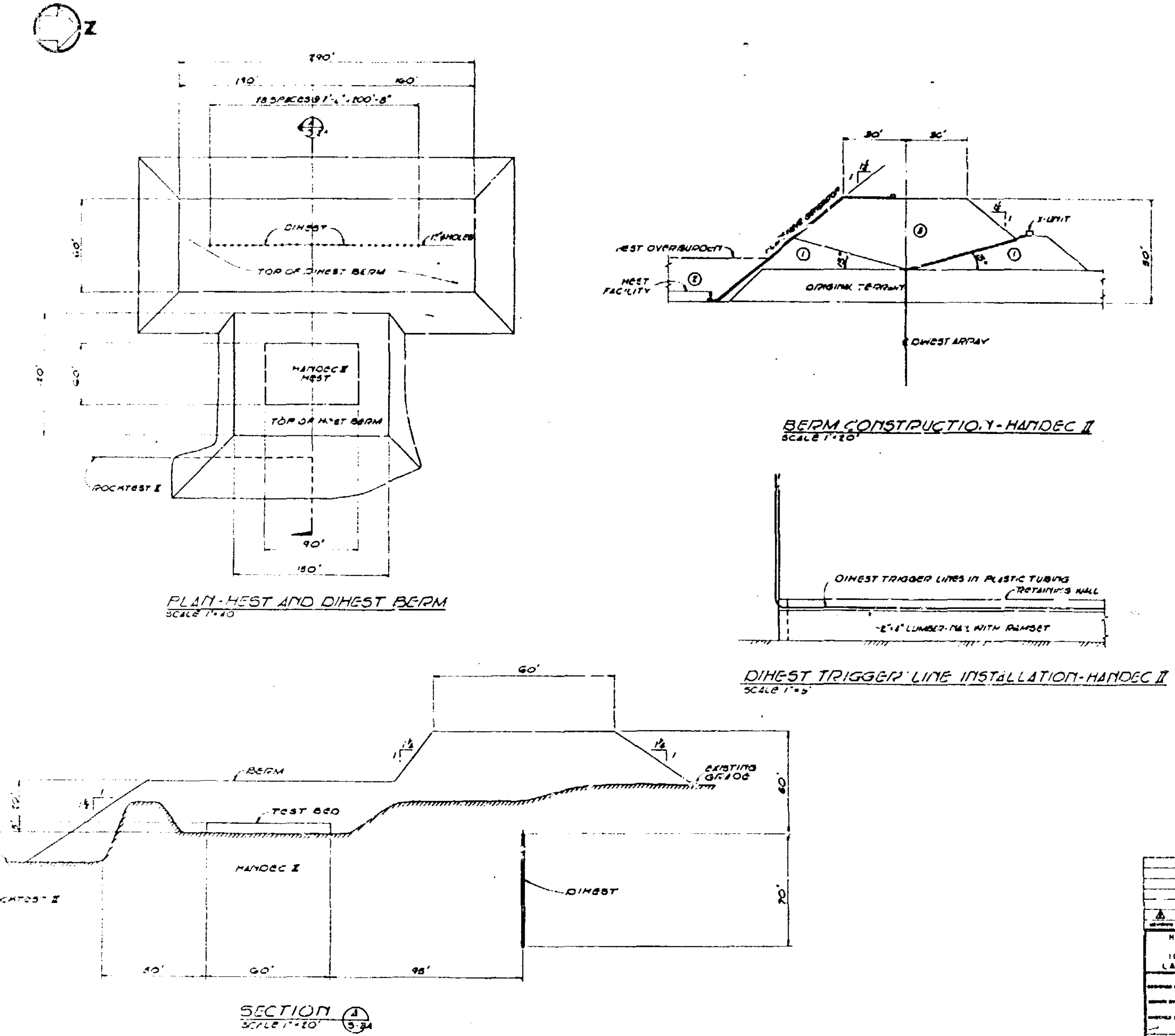

EARTH BERM
SURCHARGE
ROOF DECK
SUB-DECK
ENCLOSURE WALL
EXISTING GRADE
ELEVATION OF ROCK FLOOR SHT. S-1
SECTION A
SECTION B
COMPACT EARTH BERM TO 95% DENSITY IN ACCORDANCE WITH MODIFIED AASHO
TO BE DETERMINED BY GOVERNMENT MADE DENSITY TESTS
SURCHARGE BETWEEN SUB-DECK AND ROOF DECK
WEB DOUBLERS
SPLICE
5 LAYERS OF DETONATING CORD RACKS (TYP. EA. BAY)
NOTES
1. FINAL DEPTH OF SURCHARGE WILL BE GOVERNED BY ACTUAL MEASURED DENSITY OF MATERIAL.
2. MAXIMUM LOAD ON TEST FACILITY TO BE 2000 P.S.F.
LEGEND
CONCRETE
STEEL
ROCK
SURCHARGE
COMPACTED EARTH BACKFILL
HOWARD L. TAYLOR CIVIL ENGINEER 1016 WHITE DEER DR. LA CANADA, CALIF.
BOB RUTHERFORD GENERAL CONTRACTOR P.O. BOX 6487
HANDEC II
TEST FACILITY
CROSS SECTIONS
GRAPHIC SCALE

Figure 90



BERM CONSTRUCTION FOR HANDEC II

1. THE HANDEC II BERM IS TO BE COMPLETED IN THREE PHASES. THE FIRST PHASE CONSISTS OF CONSTRUCTING THE PORTION OF BERM LABELED 1. THIS PORTION OF THE BERM MUST BE COMPLETE BEFORE RACK INSTALLATION BEGINS.

2. AFTER THE PRIMACORD RACKS ARE INSTALLED, THE PLANEWAVE GENERATOR LEADS ARE TO BE BROUGHT STRAIGHT BACK IN TRENCHES UP THE 1 TO 1½ SLOPE. THE LEADS WILL BE PLACED OVER ONTO THE 15° SLOPE TEMPORARILY.

3. THE DIHEST TRIGGER LINES IN PLASTIC TUBING WILL RUN ALONG END OF RETAINING WALL. PLASTIC TUBING WILL BE SUPPORTED FROM BELOW BY 2"x4" LUMBER NAILED TO THE WALL WITH A RAMSET (OR BY EQUAL SATISFACTORY ANCHORING). THE TRIGGER LINES WILL BE FASTENED TO THE POLE THAT IS USED AS A CORNER MARKER AND WILL RISE VERTICALLY OUT OF THE TOP OF THE BERM.

4. THE HEST OVERBURDEN, LABELED 2, WILL NEXT BE COMPLETED.

5. AFTER THE PLANEWAVE GENERATOR LEADS HAVE BEEN PULLED BACK ONTO TOP OF THE COMPLETED HEST BERM THE DIHEST EXPLOSIVE LOADING WILL BE ACCOMPLISHED. THE DIHEST FIRING LINES PROTECTED BY PLASTIC TUBING EXTENDING FROM THE TOPS OF THE FIRING HOLES (FIRING LINES TO BE PROTECTED BY STEEL PIPE DOWNHOLE) WILL BE PLACED INTO ONE FOOT DEEP TRENCHES EXTENDING UP THE 15° SLOPE AND COMING TOGETHER IN GROUPS OF THREE (EXCEPT FOR ONE GROUP OF TWO TO BE ACCOMPLISHED AT NORTH END OF THE ARRAY).

6. THE PORTION OF THE DIHEST BERM LABELED 3 WILL BE COMPLETED.

7. THE DIHEST PORTION OF BERM WILL HAVE A LENGTH OF 290 FT ALONG THE TOP. THE BERM WILL EXTEND 160 FT. ALONG THE TOP FROM THE CENTER OF THE ARRAY TO THE NORTH AND 130 FT FROM THE CENTER OF THE ARRAY TO THE SOUTH.

ISSUED FOR CONSTRUCTION	
HOWARD TAYLOR CIVIL ENGINEER 1015 WHITE DEER DR LA CANADA CALIF	BOB RUTHERFORD GENERAL CONTRACTOR P O BOX 8467 ALBUQUERQUE, NEW MEXICO 87108
S-3A	HANDEC II EARTH BERM PLAN AND SECTIONS

Figure 91

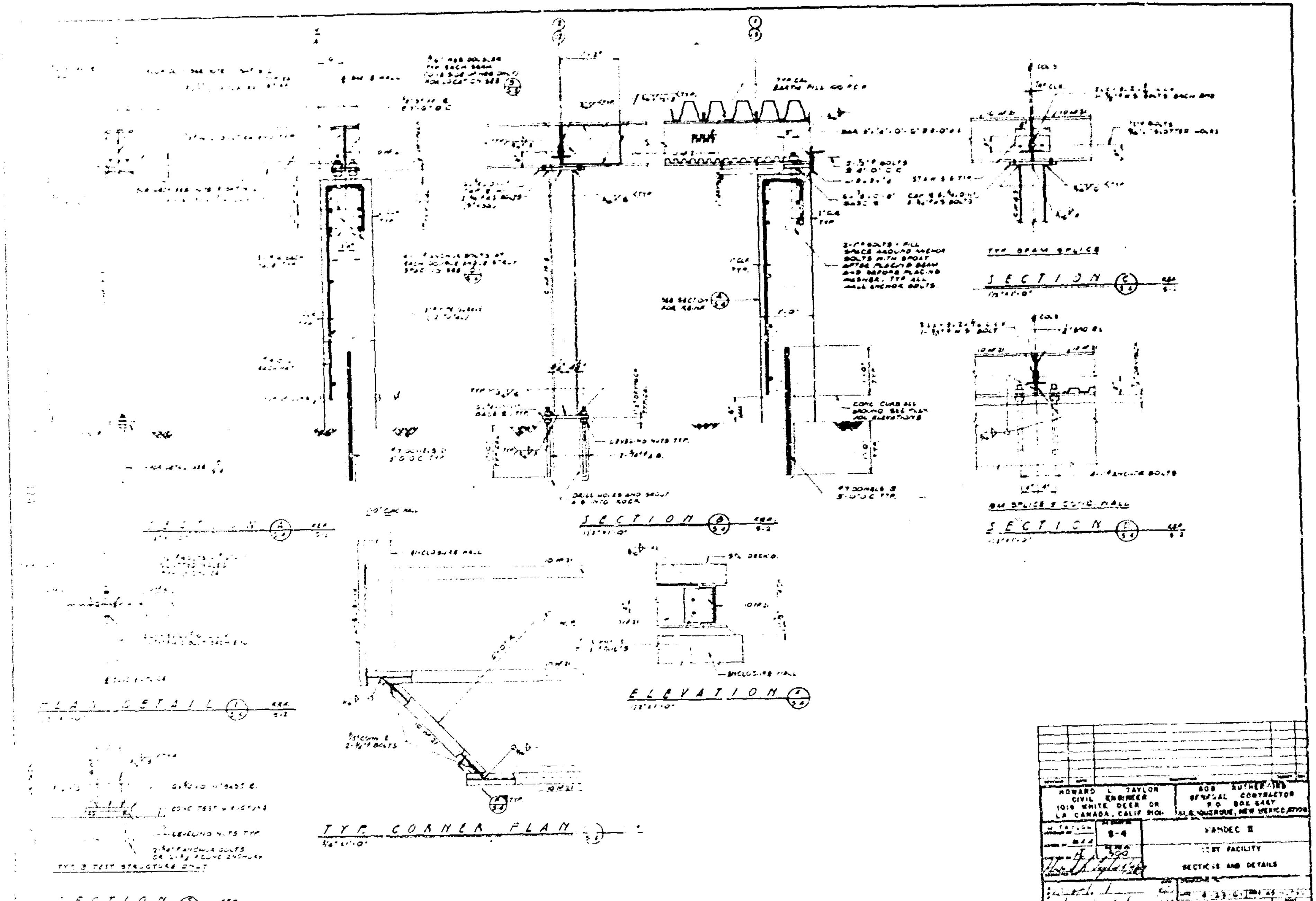
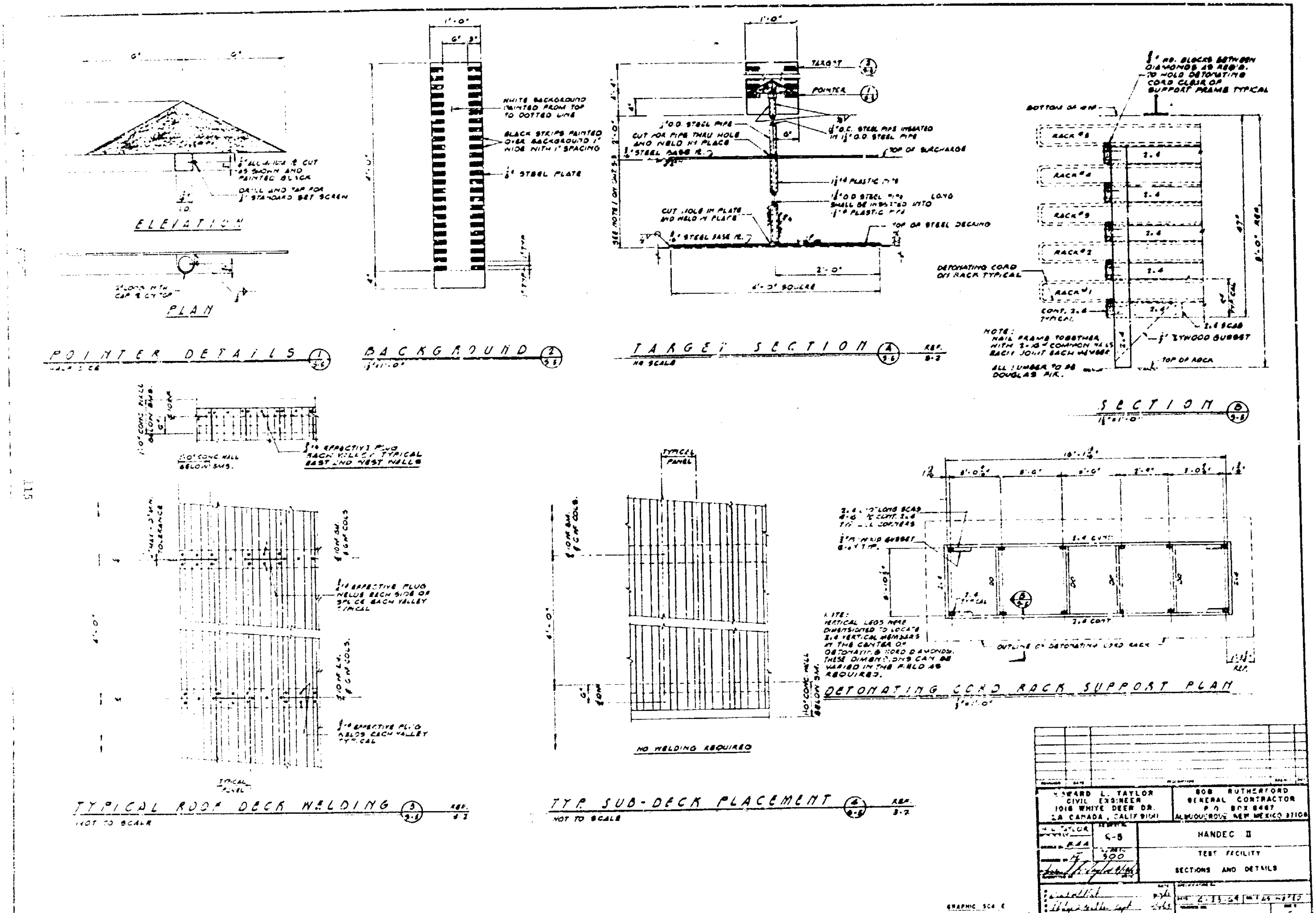

SECTION A
SECTION B
SECTION C
SECTION D
SECTION E
ELEVATION
PLAN DETAIL
TYP. CORNER PLAN
TYP. BEAM SPLICE
ENCLOSURE WALL
HOWARD L. TAYLOR
CIVIL ENGINEER
1016 WHITE DEER DR.
LA CANADA, CALIF.
BOB SUTHERLAND
GENERAL CONTRACTOR
P.O. BOX 6467
ALBUQUERQUE, NEW MEXICO
VANDEC II
TEST FACILITY
SECTIONS AND DETAILS
S-4

Figure 92


POINTER DETAILS
ELEVATION
PLAN
BACKGROUND
WHITE BACKGROUND PAINTED FROM TOP TO DOTTED LINE
BLACK STRIPS PAINTED OVER BACKGROUND 1" WIDE WITH 1" SPACING
STEEL PLATE
TARGET SECTION
NO SCALE
TARGET
POINTER
TOP OF SURCHARGE
TOP OF STEEL DECKING
CUT FOR PIPE THRU HOLE AND WELD IN PLACE
CUT HOLE IN PLATE AND WELD IN PLACE
4'-0" SQUARE
SECTION
BOTTOM OF BIN
DETONATING CORD ON RACK TYPICAL
RACK #1
RACK #2
RACK #3
RACK #4
RACK #5
TOP OF ROCK
NOTE: NAIL FRAME TOGETHER WITH 2-16d COMMON NAILS EACH JOINT EACH MEMBER
ALL LUMBER TO BE DOUGLAS FIR.
DETONATING CORD RACK SUPPORT PLAN
OUTLINE OF DETONATING CORD RACK
TYPICAL ROOF DECK WELDING
NOT TO SCALE
TYP. SUB-DECK PLACEMENT
NOT TO SCALE
TYPICAL PANEL
NO WELDING REQUIRED
HOWARD L. TAYLOR
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1016 WHITE DEER DR.
LA CANADA, CALIF.
BOB RUTHERFORD
GENERAL CONTRACTOR
P.O. BOX 8467
ALBUQUERQUE NEW MEXICO
HANDEC II
TEST FACILITY
SECTIONS AND DETAILS
S-8
GRAPHIC SCALE

Figure 93

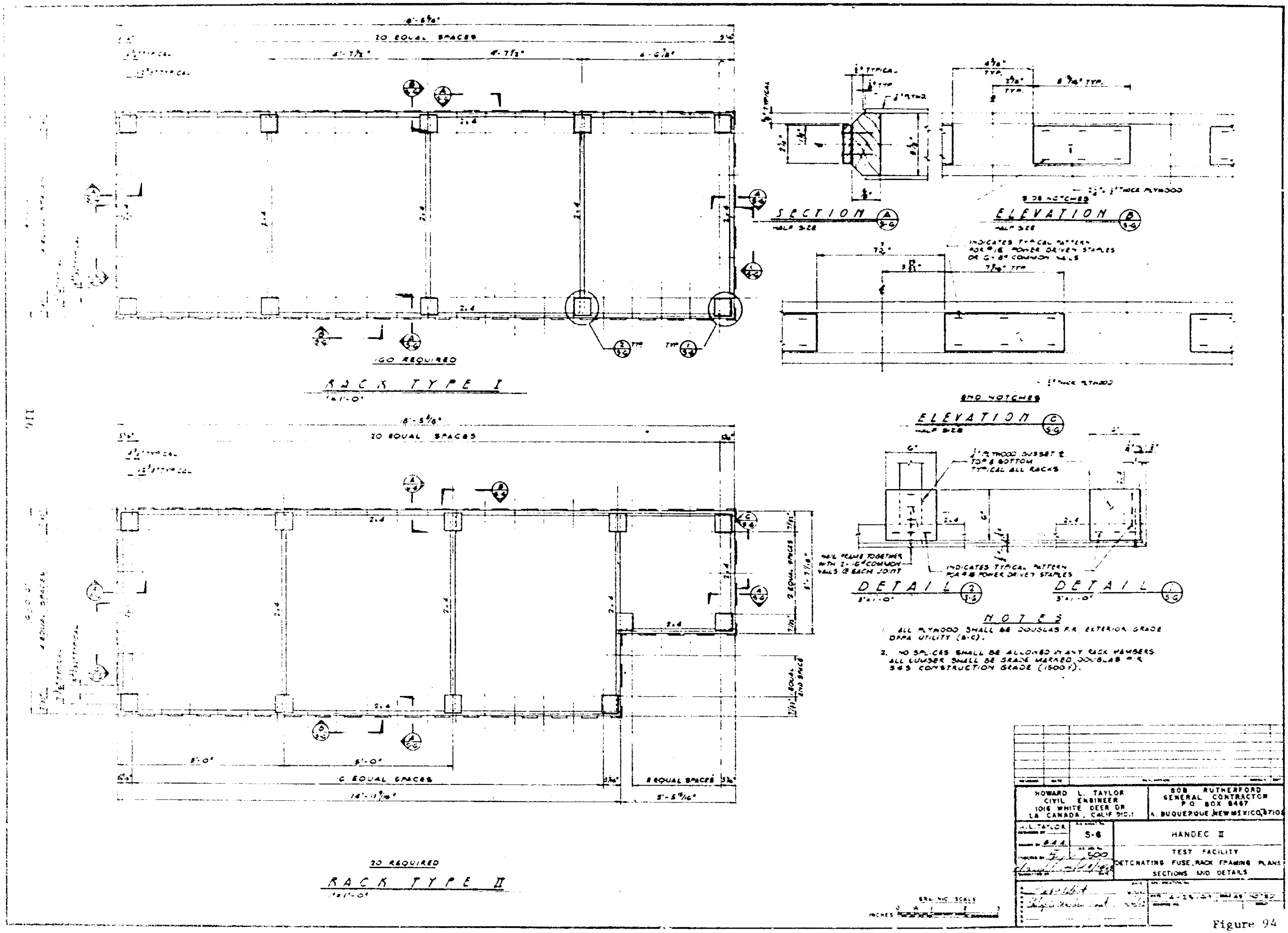
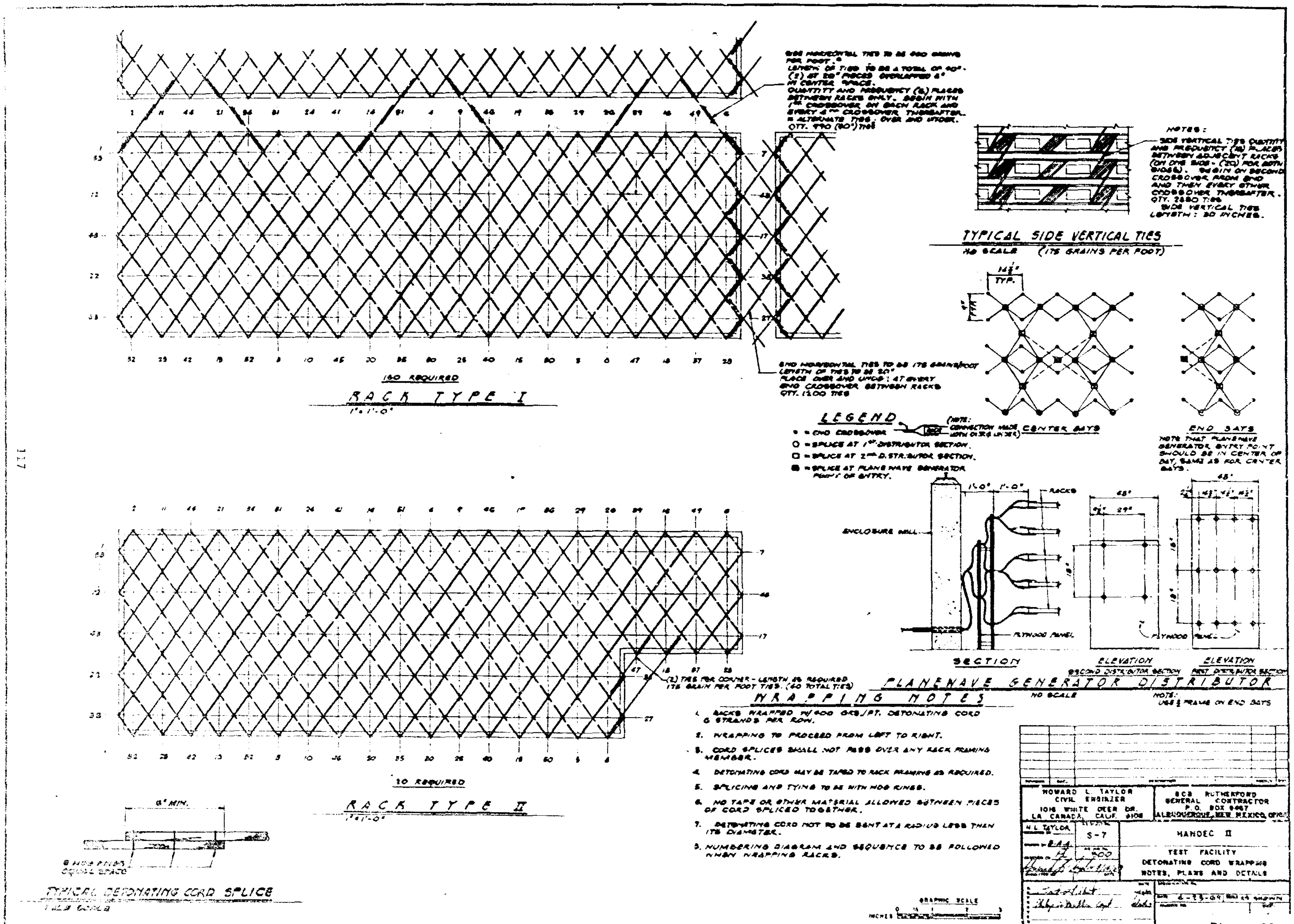

RACK TYPE I
160 REQUIRED
RACK TYPE II
20 REQUIRED
SECTION A
ELEVATION B
ELEVATION C
DETAIL 2
DETAIL 1
NOTES
1. ALL PLYWOOD SHALL BE DOUGLAS FIR EXTERIOR GRADE DFPA UTILITY (B-C).
2. NO SPLICES SHALL BE ALLOWED IN ANY RACK MEMBERS. ALL LUMBER SHALL BE GRADE MARKED DOUGLAS FIR S4S CONSTRUCTION GRADE (1500 f).
HOWARD L. TAYLOR CIVIL ENGINEER
BOB RUTHERFORD GENERAL CONTRACTOR
HANDEC II
TEST FACILITY
DETONATING FUSE, RACK FRAMING PLANS SECTIONS AND DETAILS
S-6

Figure 94



RACK TYPE I
160 REQUIRED
1" = 1'-0"
RACK TYPE II
10 REQUIRED
1" = 1'-0"
TYPICAL SIDE VERTICAL TIES
NO SCALE (175 GRAINS PER FOOT)
CENTER BAYS
END BAYS
LEGEND
SECTION
ELEVATION
ELEVATION
ENCLOSURE WALL
RACKS
PLYWOOD PANEL
PLANEWAVE GENERATOR DISTRIBUTOR
NO SCALE
WRAPPING NOTES
1. RACKS WRAPPED W/400 GRS./FT. DETONATING CORD 6 STRANDS PER ROW.
2. WRAPPING TO PROCEED FROM LEFT TO RIGHT.
3. CORD SPLICES SHALL NOT PASS OVER ANY RACK FRAMING MEMBER.
4. DETONATING CORD MAY BE TAPED TO RACK FRAMING AS REQUIRED.
5. SPLICING AND TYING TO BE WITH HOG RINGS.
6. NO TAPE OR OTHER MATERIAL ALLOWED BETWEEN PIECES OF CORD SPLICED TOGETHER.
7. DETONATING CORD NOT TO BE BENT AT A RADIUS LESS THAN ITS DIAMETER.
8. NUMBERING DIAGRAM AND SEQUENCE TO BE FOLLOWED WHEN WRAPPING RACKS.
TYPICAL DETONATING CORD SPLICE
6" MIN.
HOWARD L. TAYLOR
CIVIL ENGINEER
RCB RUTHERFORD
GENERAL CONTRACTOR
HANDEC II
TEST FACILITY
DETONATING CORD WRAPPING
NOTES, PLANS AND DETAILS
S-7
GRAPHIC SCALE

Figure 95

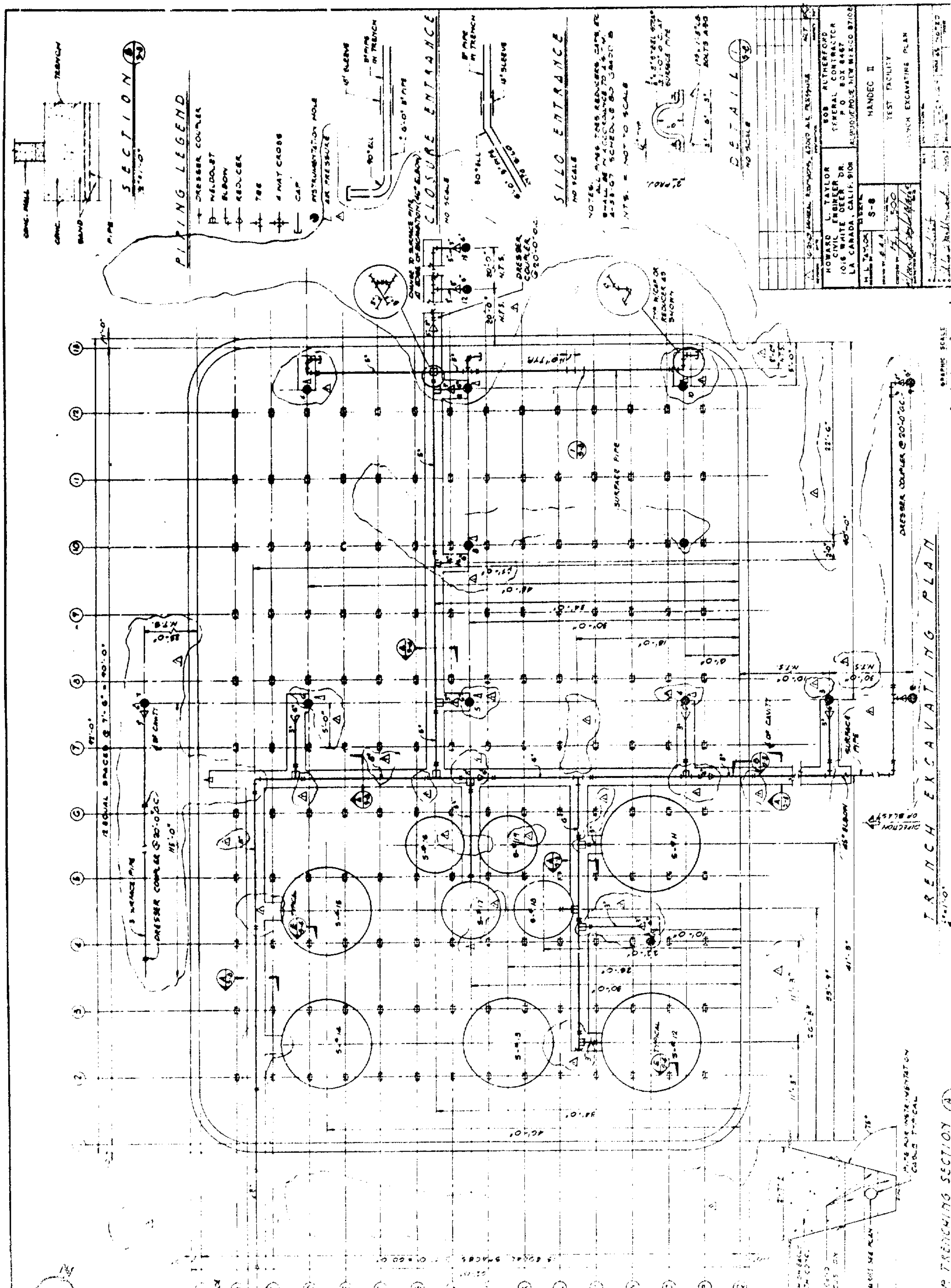
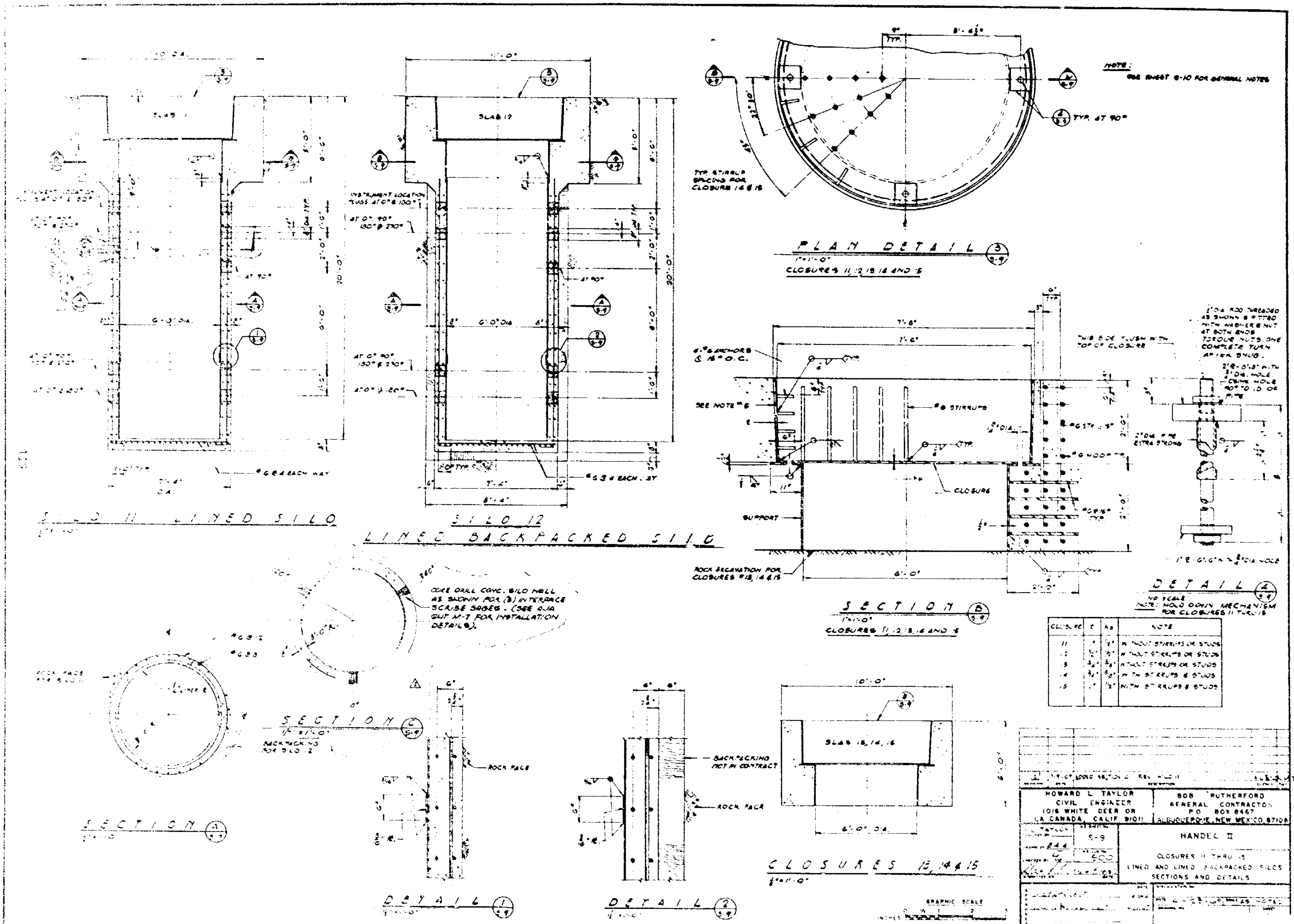

TRENCH EXCAVATING PLAN
PIPING LEGEND
SECTION
CLOSURE ENTRANCE
SILO ENTRANCE
DETAIL
TYP. TRENCHING SECTION
HANDEC II
TEST FACILITY

Figure 96


SILO 11 LINED SILO
SILO 12
LINED BACKPACKED SILO
PLAN DETAIL
CLOSURES 11, 12, 13, 14 AND 15
SECTION
CLOSURES 11, 12, 13, 14 AND 15
DETAIL
NO SCALE
NOTE: HOLD DOWN MECHANISM FOR CLOSURES 11 THRU 15
SECTION
SECTION
DETAIL
DETAIL
CLOSURES 13, 14 & 15
NOTE: SEE SHEET S-10 FOR GENERAL NOTES
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GENERAL CONTRACTOR
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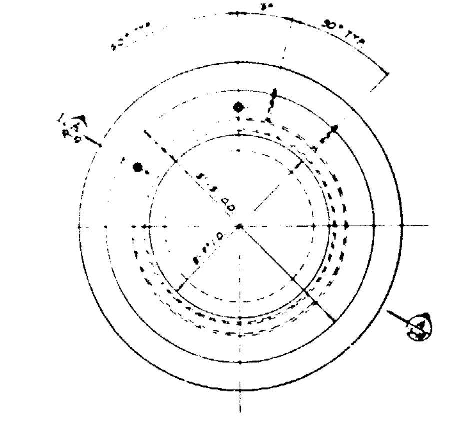
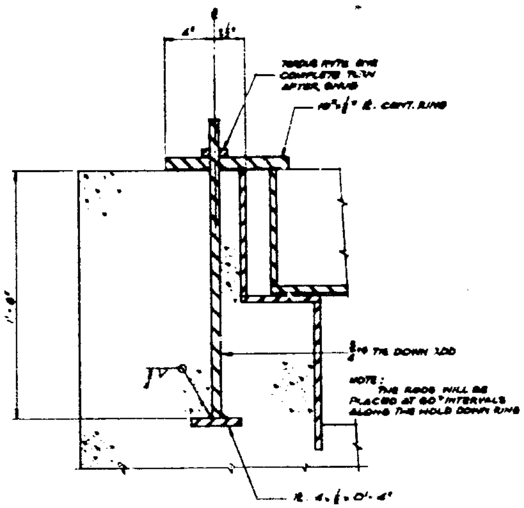
HANDEC II
CLOSURES 11 THRU 15
LINED AND LINED BACKPACKED SILOS
SECTIONS AND DETAILS
S-9
GRAPHIC SCALE

Figure 97



PLAN CLOSURES 16 THRU 19

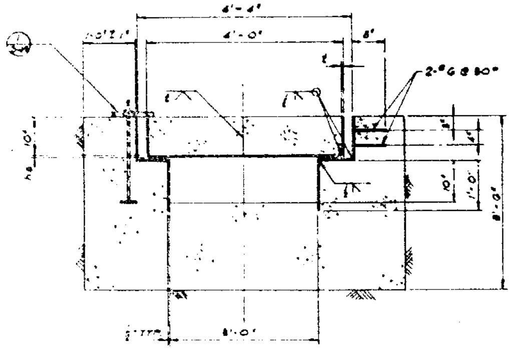
1"=1'-0"



DETAIL 1/S-10

3"=1'-0"

CLOS. NO	hs	t
16	5/16	0
17	5/16	1/16
18	3/16	1/8
19	0	3/8



SECTION A/S-10

1"=1'-0"

GENERAL NOTES

SHEETS S-9 AND S-10 ONLY

1. STEEL-A-36.
2. MIN. CONCRETE STRENGTH - 4000 PSI @ 28 DAYS
3. MIN. YIELD STRENGTH OF REINFORCEMENT 40,000 PSI.
4. FULL GROOVE WELDS IN PLATES
5. OUTSIDE OF CLOSURE TO BE SANDBLASTED AND COATED WITH NON-STICK COMPOUND BEFORE POURING FOUNDATION
6. LIFTING HOOKS FOR CLOSURES TO BE PROVIDED BY CONTRACTOR.
7. CONTRACTOR WILL PROVIDE ALL MATERIALS.
8. CONTRACTOR WILL PROVIDE 8" CONDUIT FOR INSTRUMENTATION ACCESS INTO STRUCTURES.

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S-10

HANDEC II

CLOSURES 16 THRU 19
GENERAL NOTES
PLAN, SECTION AND DETAIL

Figure 98

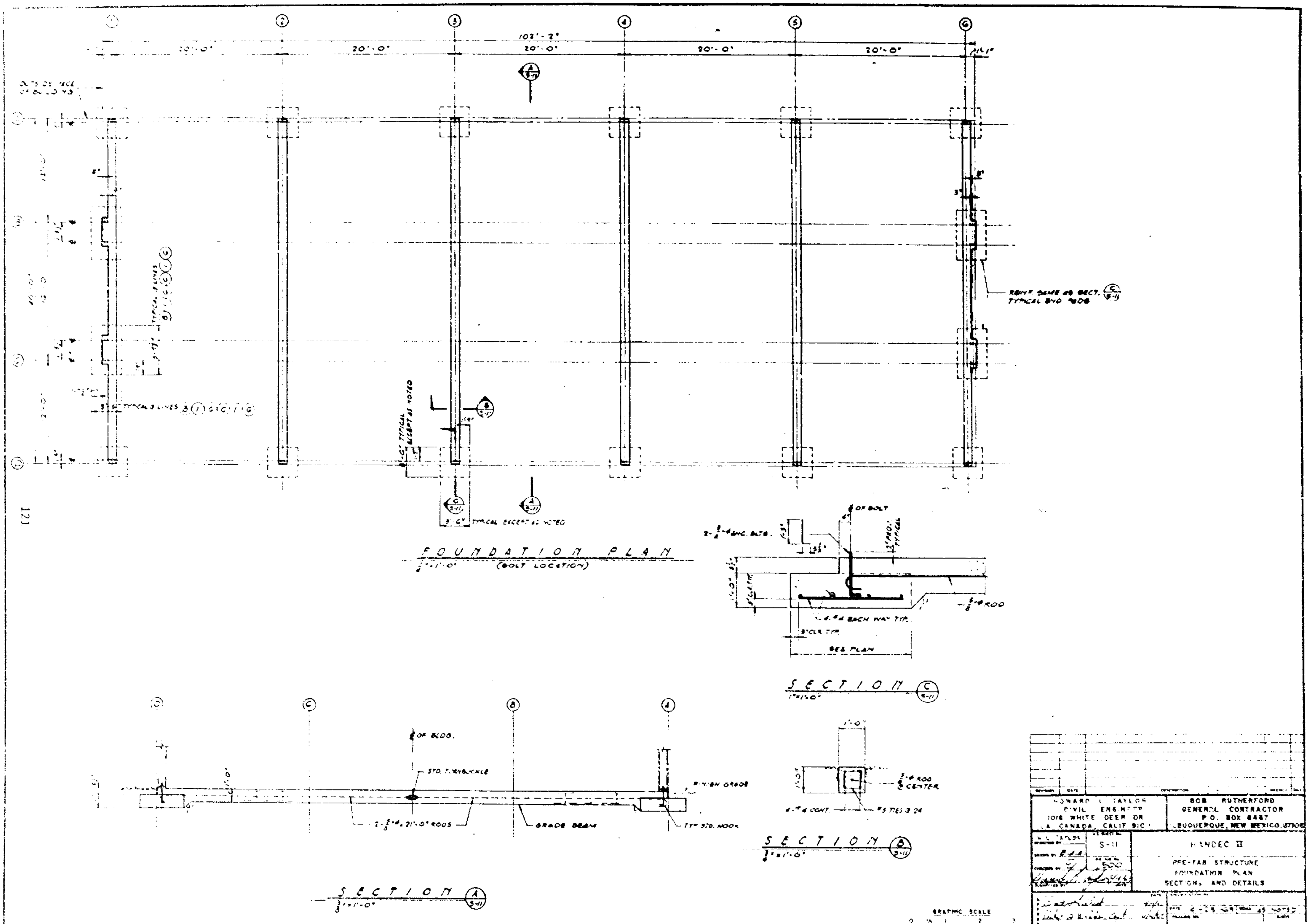
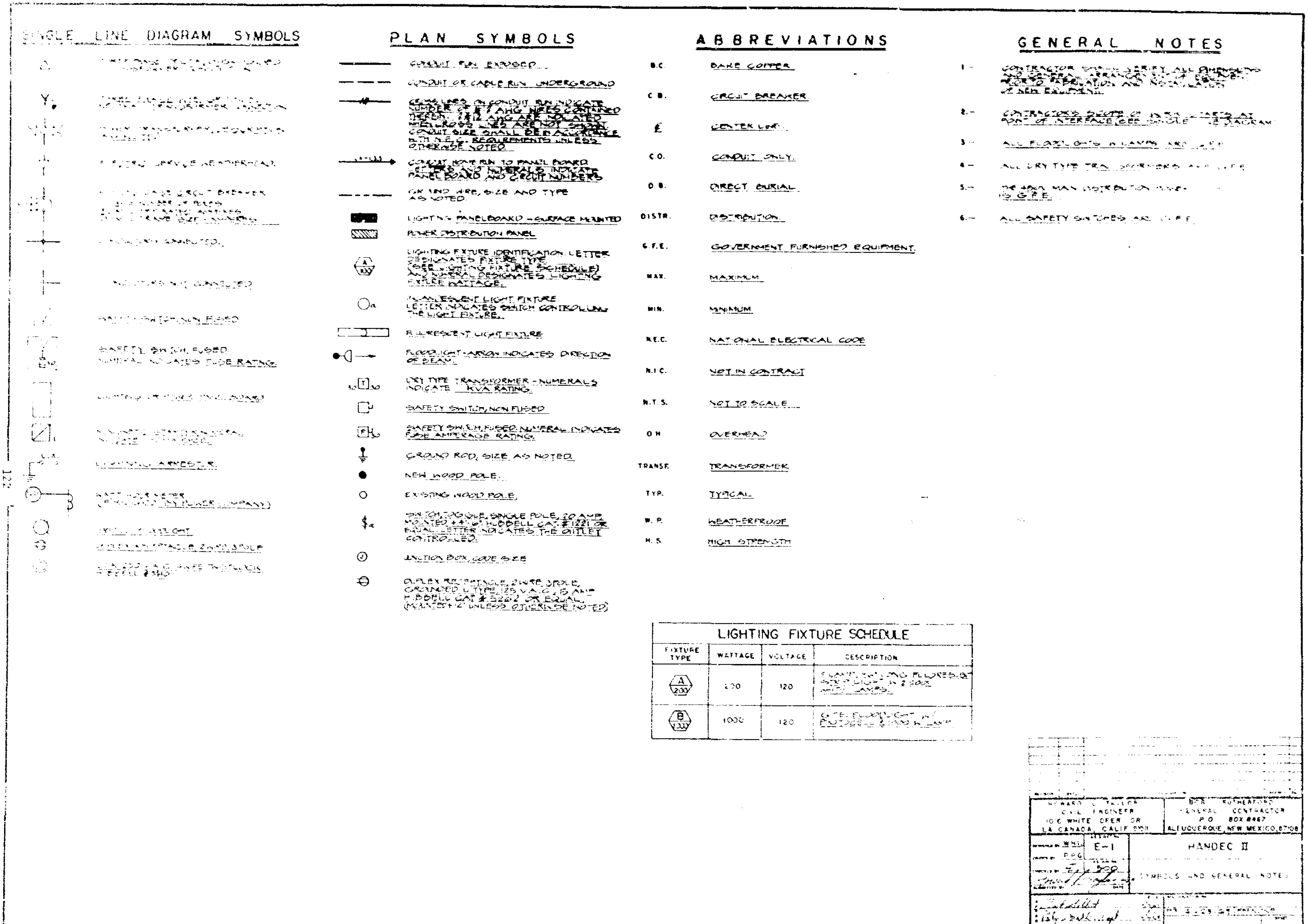

FOUNDATION PLAN
(BOLT LOCATION)
SECTION C S-11
SECTION B S-11
SECTION A S-11
GRADE BEAM
STD. TURNBUCKLE
FINISH GRADE
TYP. STD. HOOK
SEE PLAN
GRAPHIC SCALE
HOWARD L. TAYLOR
CIVIL ENGINEER
1016 WHITE DEER DR
LA CANADA, CALIF
BOB RUTHERFORD
GENERAL CONTRACTOR
P.O. BOX 8467
ALBUQUERQUE, NEW MEXICO
HANDEC II
PRE-FAB STRUCTURE
FOUNDATION PLAN
SECTIONS AND DETAILS
S-11

Figure 99



SINGLE LINE DIAGRAM SYMBOLS
SAFETY SWITCH, FUSED
LIGHTNING ARRESTER
PLAN SYMBOLS
CONDUIT RUN EXPOSED
CONDUIT OR CABLE RUN UNDERGROUND
CROSS LINES ON CONDUIT RUN INDICATE NUMBER OF #12 AHG WIRES CONTAINED THEREIN. 2#12 AWG ARE INDICATED WHEN CROSS LINES ARE NOT SHOWN. CONDUIT SIZE SHALL BE IN ACCORDANCE WITH N.E.C. REQUIREMENTS UNLESS OTHERWISE NOTED.
CONDUIT HOME RUN TO PANEL BOARD LETTERS AND NUMERALS INDICATE PANEL BOARD AND CIRCUIT NUMBERS
GROUND WIRE, SIZE AND TYPE AS NOTED.
LIGHTING PANELBOARD - SURFACE MOUNTED
POWER DISTRIBUTION PANEL
LIGHTING FIXTURE IDENTIFICATION LETTER DESIGNATES FIXTURE TYPE (SEE LIGHTING FIXTURE SCHEDULE) AND NUMERAL DESIGNATES LIGHTING FIXTURE WATTAGE.
INCANDESCENT LIGHT FIXTURE. LETTER INDICATES SWITCH CONTROLLING THE LIGHT FIXTURE.
FLUORESCENT LIGHT FIXTURE
FLOODLIGHT-ARROW INDICATES DIRECTION OF BEAM.
DRY TYPE TRANSFORMER - NUMERALS INDICATE KVA RATING.
SAFETY SWITCH, NON FUSED
SAFETY SWITCH, FUSED. NUMERAL INDICATES FUSE AMPERAGE RATING.
GROUND ROD, SIZE AS NOTED.
NEW WOOD POLE.
EXISTING WOOD POLE.
SWITCH, TOGGLE, SINGLE POLE, 20 AMP. MOUNTED +4'-6" HUBBELL CAT. #1221 OR EQUAL. LETTER INDICATES THE OUTLET CONTROLLED.
JUNCTION BOX, CODE SIZE
DUPLEX RECEPTACLE, 2 WIRE, 3 POLE, GROUNDED U TYPE, 125 V.A.C., 15 AMP HUBBELL CAT #5262 OR EQUAL. (MOUNTED +12" UNLESS OTHERWISE NOTED)
ABBREVIATIONS
B.C. BARE COPPER
C.B. CIRCUIT BREAKER
℄ CENTER LINE
C.O. CONDUIT ONLY
D.B. DIRECT BURIAL
DISTR. DISTRIBUTION
G.F.E. GOVERNMENT FURNISHED EQUIPMENT
MAX. MAXIMUM
MIN. MINIMUM
N.E.C. NATIONAL ELECTRICAL CODE
N.I.C. NOT IN CONTRACT
N.T.S. NOT TO SCALE
O.H. OVERHEAD
TRANSF. TRANSFORMER
TYP. TYPICAL
W.P. WEATHERPROOF
H.S. HIGH STRENGTH
GENERAL NOTES
1.- CONTRACTOR SHALL VERIFY ALL DIMENSIONS AND GENERAL ARRANGEMENT OF EQUIPMENT PRIOR TO FABRICATION AND INSTALLATION OF NEW EQUIPMENT.
2.- CONTRACTOR'S SCOPE OF INSTALLATION STARTS AT POINT OF INTERFACE (SEE SINGLE LINE DIAGRAM)
3.- ALL FLOODLIGHTS W LAMPS ARE G.F.E.
4.- ALL DRY TYPE TRANSFORMERS ARE G.F.E.
5.- THE MAIN DISTRIBUTION PANEL IS G.F.E.
6.- ALL SAFETY SWITCHES ARE G.F.E.
LIGHTING FIXTURE SCHEDULE
FIXTURE TYPE
WATTAGE
VOLTAGE
DESCRIPTION
A 200
200
120
B 1000
1000
120
HOWARD L. TAYLOR
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BOB RUTHERFORD
GENERAL CONTRACTOR
P.O. BOX #467
ALBUQUERQUE, NEW MEXICO, 87108
E-1
HANDEC II
SYMBOLS AND GENERAL NOTES

Figure 100

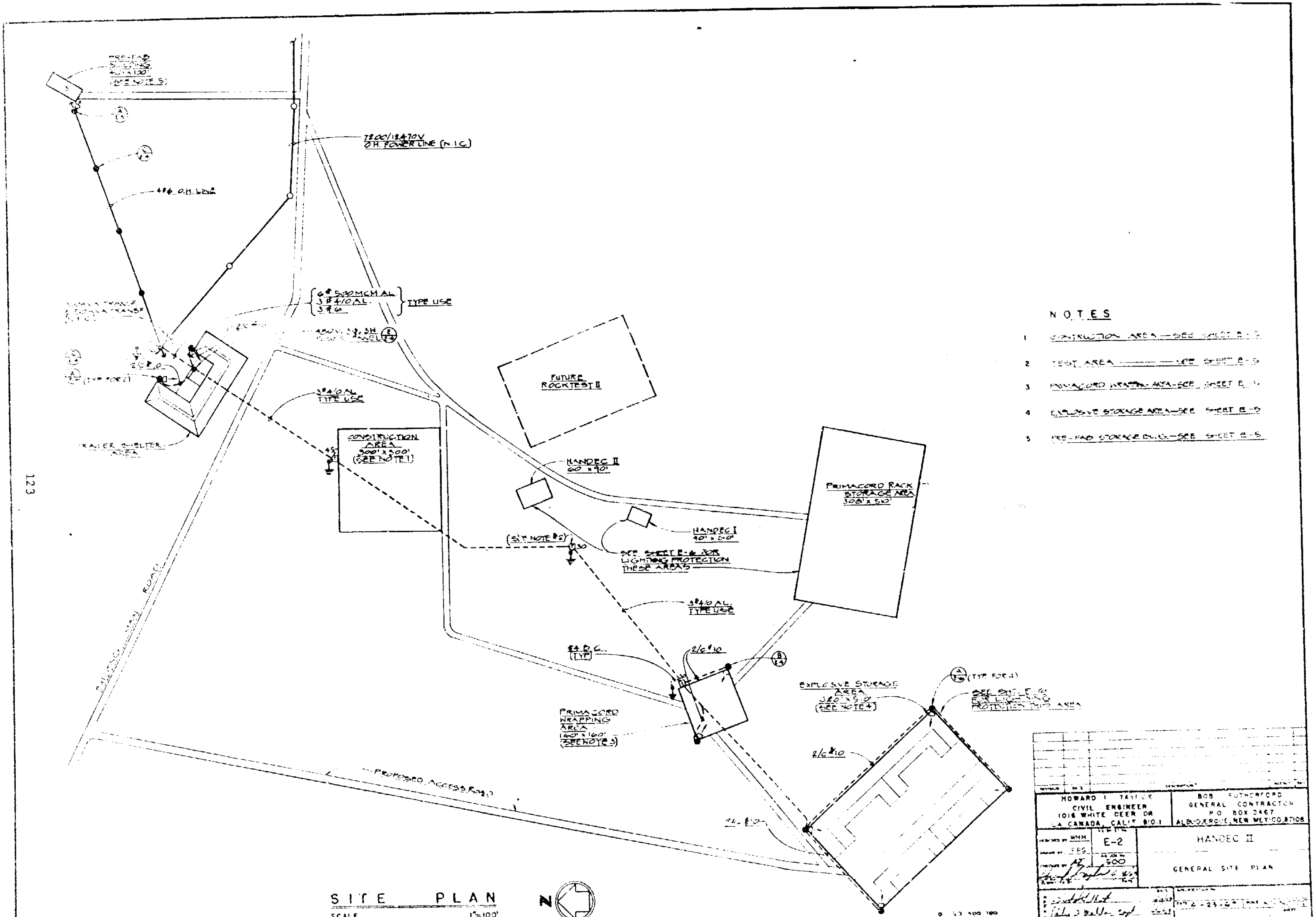
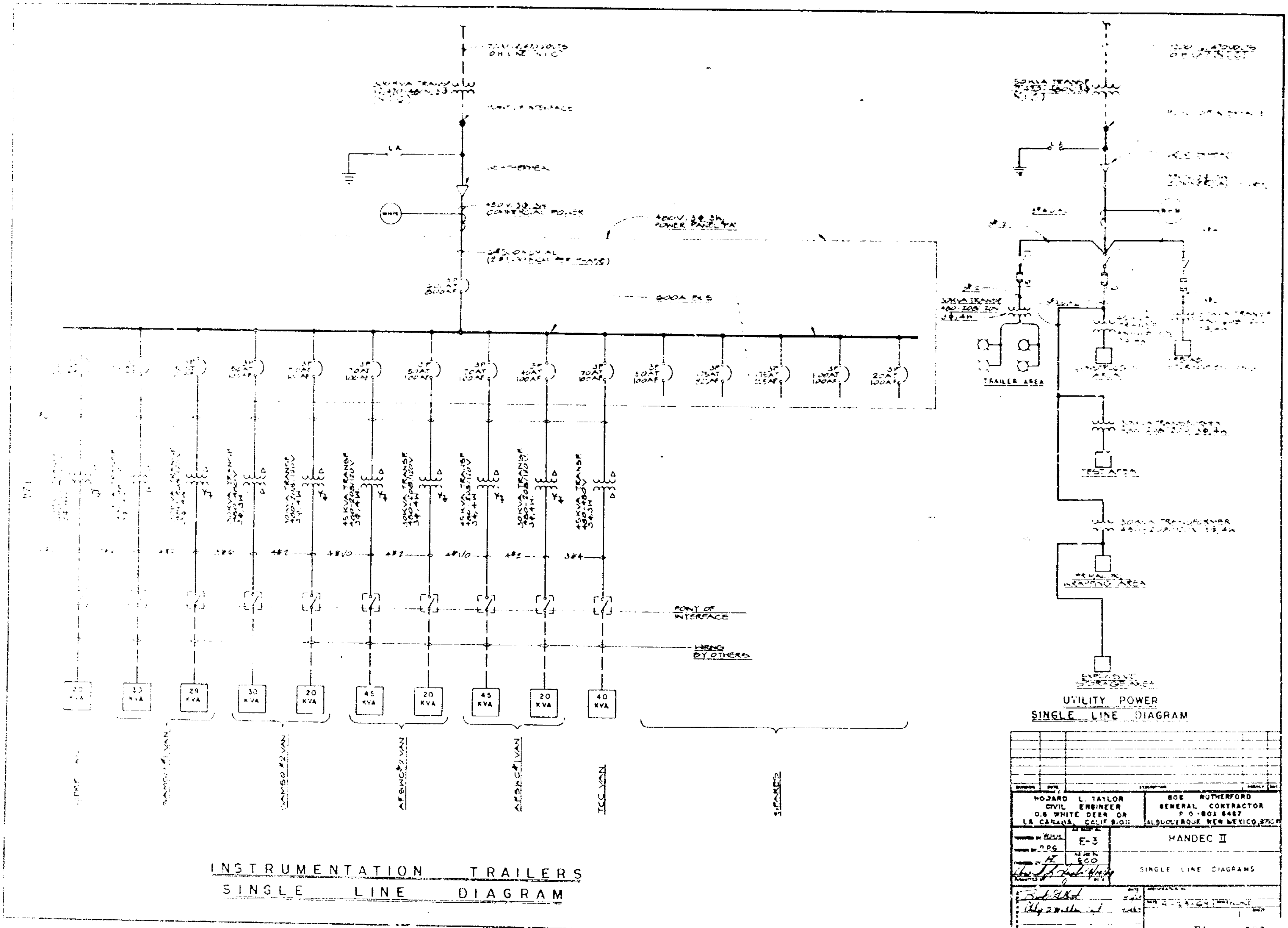

NOTES
1 CONSTRUCTION AREA — SEE SHEET E-3
2 TEST AREA — SEE SHEET E-5
4 EXPLOSIVE STORAGE AREA — SEE SHEET E-5
5 PRE-FAB STORAGE BLDG. — SEE SHEET E-5
7200/12470V O.H. POWER LINE (N.I.C.)
TYPE USE
FUTURE ROCKTEST II
CONSTRUCTION AREA 300' x 300' (SEE NOTE 1)
HANDEC II 60' x 90'
HANDEC I 40' x 60'
SEE SHEET E-6 FOR LIGHTNING PROTECTION THESE AREAS
PRIMACORD RACK STORAGE AREA 308' x 5x2'
3#4/0 AL. TYPE USE
PRIMACORD WRAPPING AREA 160' x 160' (SEE NOTE 3)
EXPLOSIVE STORAGE AREA (SEE NOTE 4)
PROPOSED ACCESS ROAD
TRAILER SHELTER AREA
SITE PLAN
SCALE 1"=100'
HOWARD I. TAYLOR CIVIL ENGINEER 1016 WHITE CEER DR LA CANADA, CALIF.
BOB RUTHERFORD GENERAL CONTRACTOR P.O. BOX 3467 ALBUQUERQUE, NEW MEXICO 87108
E-2
HANDEC II
GENERAL SITE PLAN

Figure 101


INSTRUMENTATION TRAILERS
SINGLE LINE DIAGRAM
UTILITY POWER
SINGLE LINE DIAGRAM
POINT OF INTERFACE
WIRING BY OTHERS
TRAILER AREA
TEST AREA
SPARES
TCC VAN
20 KVA
30 KVA
29 KVA
45 KVA
40 KVA
HOWARD L. TAYLOR
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BOB RUTHERFORD
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P.O. BOX 8487
ALBUQUERQUE, NEW MEXICO
E-3
HANDEC II
SINGLE LINE DIAGRAMS

Figure 102

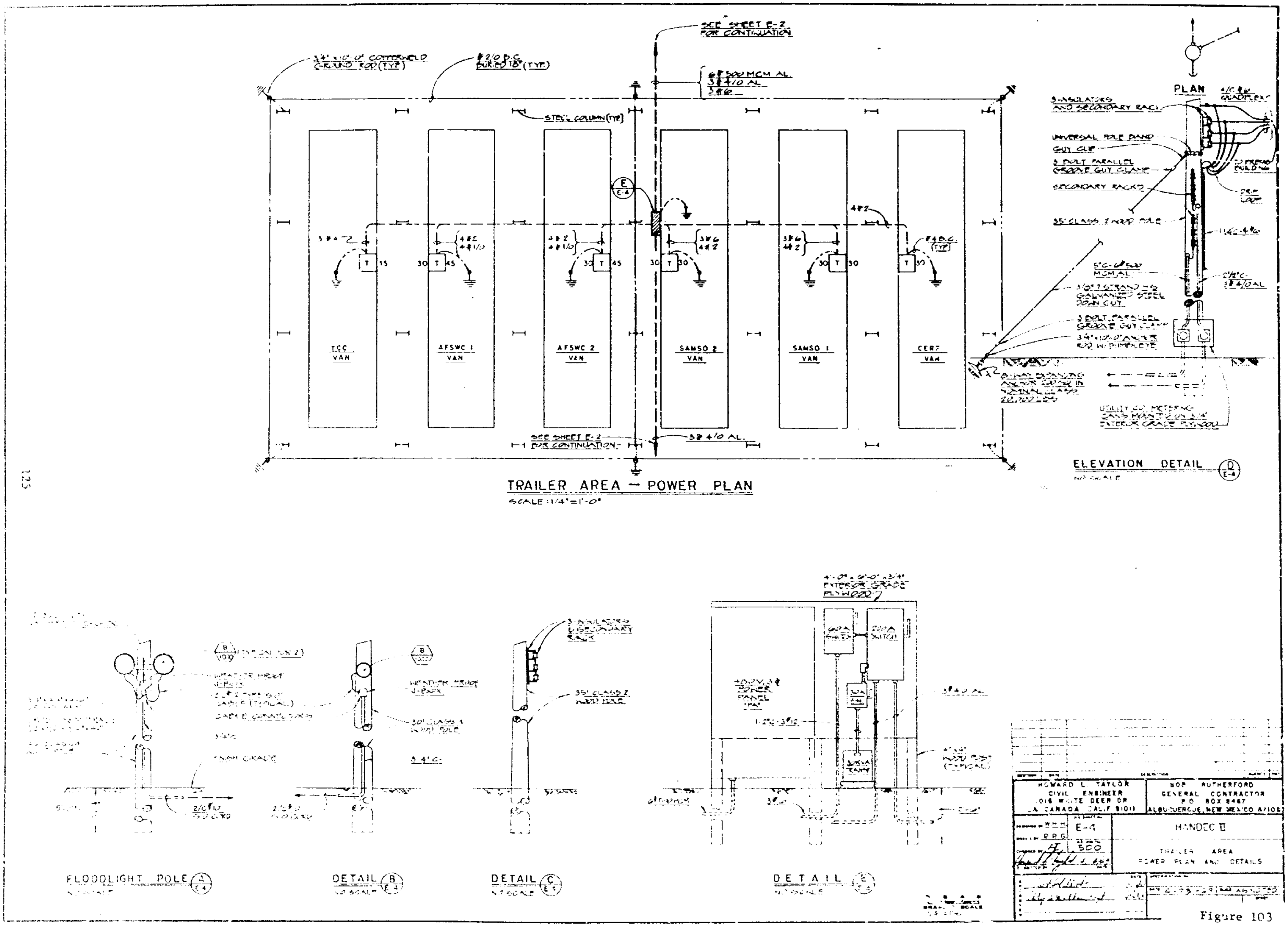

TRAILER AREA — POWER PLAN
SCALE: 1/4"=1'-0"
SEE SHEET E-2 FOR CONTINUATION
STEEL COLUMN (TYP)
TCC VAN
AFSWC 1 VAN
AFSWC 2 VAN
SAMSO 2 VAN
SAMSO 1 VAN
CER7 VAN
PLAN
ELEVATION DETAIL
SECONDARY RACKS
35' CLASS 2 WOOD POLE
FLOODLIGHT POLE
DETAIL
HOWARD L. TAYLOR
CIVIL ENGINEER
BOB RUTHERFORD
GENERAL CONTRACTOR
P.O. BOX 8467
E-4
MINDEC II
TRAILER AREA
POWER PLAN AND DETAILS

Figure 103

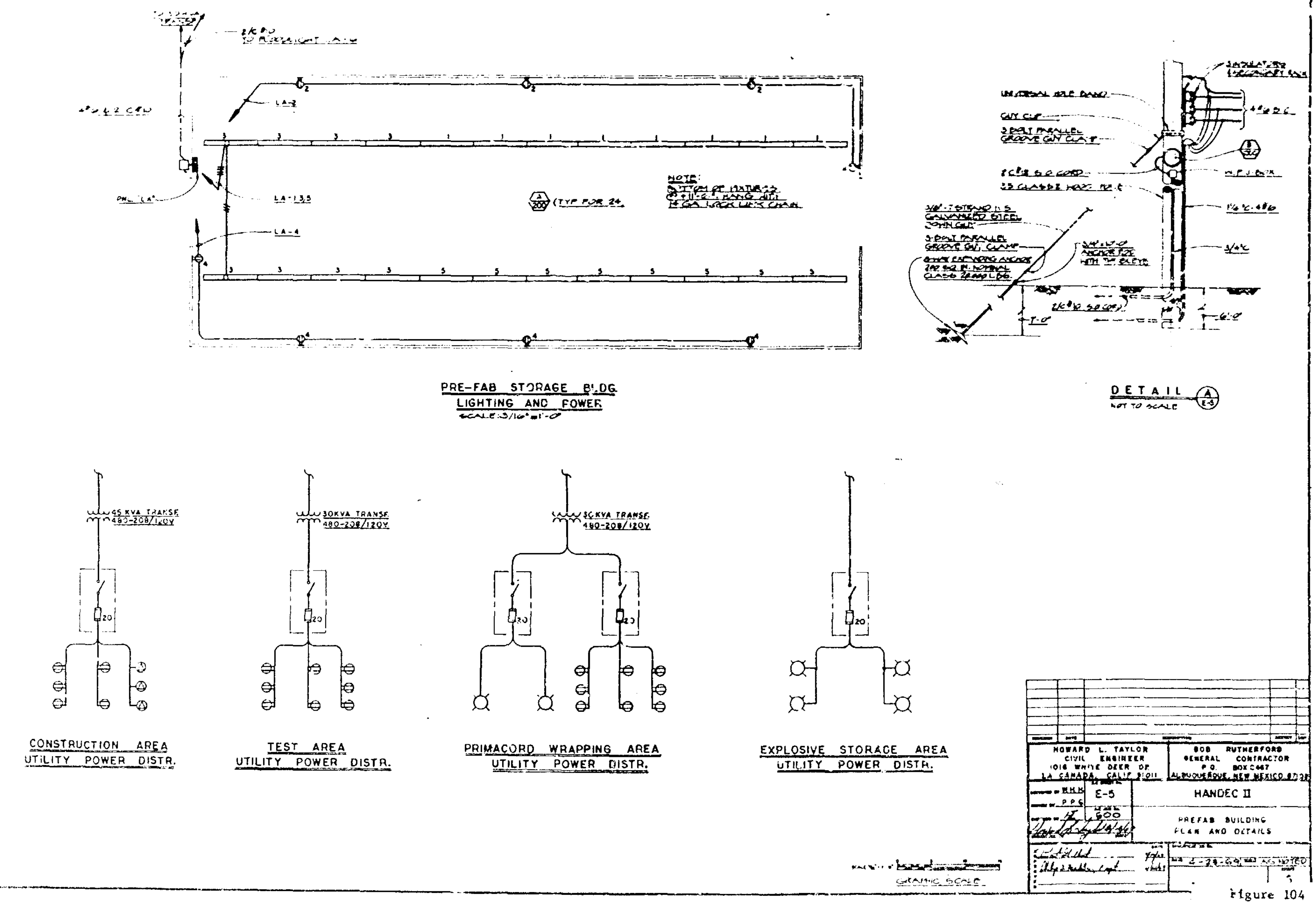
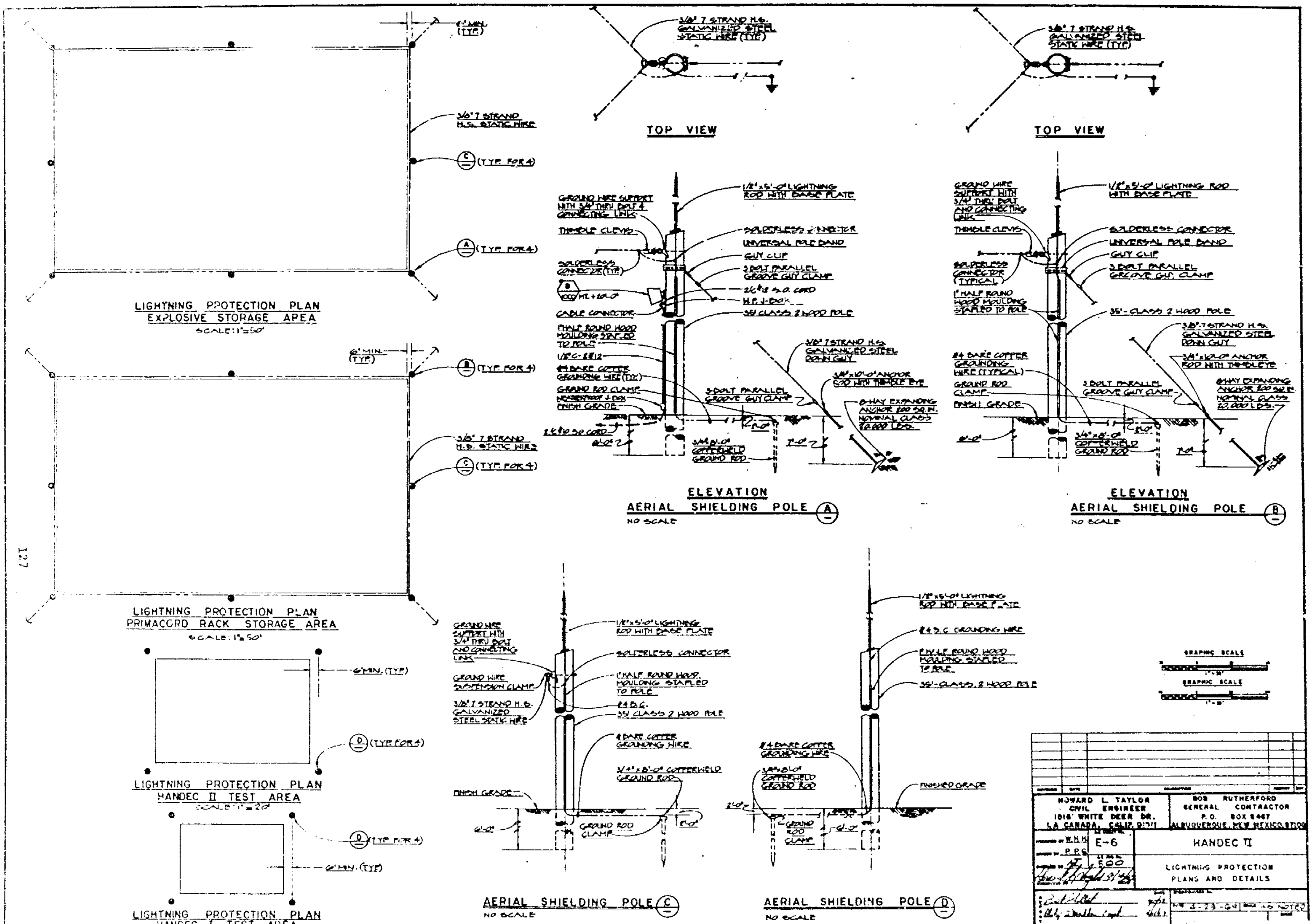

PRE-FAB STORAGE B'LDG.
LIGHTING AND POWER
LA-2
LA-1,3,5
LA-4
(TYP FOR 24)
NOTE:
DETAIL A
NOT TO SCALE
3/4"C
6'-0"
CONSTRUCTION AREA
UTILITY POWER DISTR.
45 KVA TRANSF.
480-208/120V
TEST AREA
UTILITY POWER DISTR.
30KVA TRANSF.
480-208/120V
PRIMACORD WRAPPING AREA
UTILITY POWER DISTR.
30KVA TRANSF.
480-208/120V
EXPLOSIVE STORAGE AREA
UTILITY POWER DISTR.
20
HOWARD L. TAYLOR
CIVIL ENGINEER
BOB RUTHERFORD
GENERAL CONTRACTOR
P.O. BOX C467
ALBUQUERQUE, NEW MEXICO
E-5
HANDEC II
PREFAB BUILDING
PLAN AND DETAILS
GRAPHIC SCALE

Figure 104



LIGHTNING PROTECTION PLAN
EXPLOSIVE STORAGE AREA
SCALE: 1"=50'
LIGHTNING PROTECTION PLAN
PRIMACORD RACK STORAGE AREA
SCALE: 1"=50'
LIGHTNING PROTECTION PLAN
HANDEC II TEST AREA
SCALE: 1"=20'
LIGHTNING PROTECTION PLAN
HANDEC I TEST AREA
6' MIN. (TYP)
3/8" 7 STRAND H.S. STATIC WIRE
(TYP. FOR 4)
TOP VIEW
3/8" 7 STRAND H.S. GALVANIZED STEEL STATIC WIRE (TYP)
1/2"x5'-0" LIGHTNING ROD WITH BASE PLATE
GROUND WIRE SUPPORT WITH 3/4" THRU BOLT & CONNECTING LINK
THIMBLE CLEVIS
SOLDERLESS CONNECTOR
UNIVERSAL POLE BAND
GUY CLIP
3 BOLT PARALLEL GROOVE GUY CLAMP
35' CLASS 2 WOOD POLE
CABLE CONNECTOR
HALF ROUND WOOD MOULDING STAPLED TO POLE
#4 BARE COPPER GROUNDING WIRE (TYP)
GROUND ROD CLAMP
FINISH GRADE
3/8" 7 STRAND H.S. GALVANIZED STEEL DOWN GUY
3/4"x10'-0" ANCHOR ROD WITH THIMBLE EYE
8-WAY EXPANDING ANCHOR 200 SQ. IN. NOMINAL CLASS 20,000 LBS.
3/4"x8'-0" COPPERWELD GROUND ROD
ELEVATION
AERIAL SHIELDING POLE A
NO SCALE
AERIAL SHIELDING POLE B
AERIAL SHIELDING POLE C
AERIAL SHIELDING POLE D
GROUND WIRE SUSPENSION CLAMP
FINISHED GRADE
GRAPHIC SCALE
HOWARD L. TAYLOR
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1016 WHITE DEER DR.
LA CANADA, CALIF.
BOB RUTHERFORD
GENERAL CONTRACTOR
P.O. BOX 8467
ALBUQUERQUE, NEW MEXICO
E-6
HANDEC II
LIGHTNING PROTECTION
PLANS AND DETAILS

Figure 105

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APPENDIX V

SURVEYS

HANDEC II

POST TEST SURVEY

PERMANENT VERTICAL DISPLACEMENT*

Location No.	LOCATION Distance and Direction from North-East Corner (Inside) (ft.) S	W	Change in Elevation (Positive) (In.)	REMARKS
1	30.00	2.00	3.74	Rock
2	0.00	6.00	Lost	Trench
3	37.50	6.00	5.60	Trench
4	60.00	6.00	4.94	Rock
5	75.00	6.00	5.41	Rock
6	41.25	12.00	5.00	Trench
7	11.25	14.00	4.98	S#14 center(Structure#14 Center)
8	15.08	14.00	4.99	S#14 edge
9	26.25	14.00	4.30	S#15 center
10	30.08	14.00	4.89	S#15 edge
11	88.00	16.00	5.95	Top of surface pipe
12	60.00	18.00	10.58	Rock
13	75.00	18.00	6.74	Rock
14	15.00	22.00	5.17	Rock
15	33.75	26.00	Lost	S#16 center
16	36.50	26.00	7.04	S#16 edge
17	45.00	26.00	8.60	Trench
18	75.00	26.00	15.61	Trench
19	26.25	30.00	Lost	S#17 center
20	29.00	30.00	7.34	S#17 edge
21	41.25	30.00	5.65	Trench
22	11.25	34.00	6.61	S#13 center
23	15.08	34.00	6.74	S#13 edge
24	33.75	34.00	Lost	S#19 center
25	36.50	34.00	7.97	S#19 edge
26	52.50	34.00	25.30	Rock
27	26.25	38.00	Lost	S#18 center
28	29.00	38.00	8.50	S#18 edge
29	37.50	38.00	8.54	Concrete
30	75.00	38.00	22.40	Rock
31A	15.00	42.00	10.10	Trench
31B	30.00	42.00	8.00	Trench

*See Figure 106

Location No.	LOCATION Distance and Direction from North-East Corner (Inside) (ft.)		Change in Elevation (Positive) (In.)	REMARKS
	S	W		
32	88.00	44.00	9.30	Top of surface pipe
33	11.25	50.00	10.70	S#12 center
34	15.08	50.00	11.40	S#12 edge
35	33.75	50.00	10.50	S#11 center
36	37.58	50.00	10.32	S#11 edge
37	75.00	50.00	17.30	Rock
38	41.25	54.00	12.88	Trench
39	52.50	54.00	18.41	Rock
40	52.50	58.00	15.70	Rock

HANDEC II

POST TEST SURVEY

PERMANENT HORIZONTAL DISPLACEMENT*

LOCATION **	Displacement in North Direction (ft)	Displacement in East Direction (ft)	LOCATION*	Displacement in North Direction (ft)	Displacement in East Direction (ft)
101	1.10	0.83	501	0.77	0.90
102	0.93	1.04	502	0.83	0.89
103	1.04	0.87	504	0.77	0.87
104	1.02	0.87	505	0.79	0.92
107	0.83	0.68	507	0.76	0.93
108	0.91	0.82	511	0.71	0.69
113	0.72	0.82	512	0.63	0.66
			513	0.74	0.69
201	0.98	0.63	514	0.85	0.73
202	0.95	0.96			
203	0.97	0.80	601	0.78	0.92
208	0.80	0.67	602	0.80	0.98
209	0.71	0.69	603	0.79	0.95
213	0.84	0.82	606	0.66	0.97
			607	0.49	0.92
301	0.87	0.89	612	0.32	2.66
302	0.92	0.84	614	0.38	2.67
307	0.78	0.56			
308	0.75	0.74	701	0.77	0.99
310	0.71	0.78	702	0.85	1.13
313	0.80	0.70	703	0.81	1.04
			704	0.60	1.04
401	0.84	0.94	706	0.73	1.10
402	0.85	0.89	707	0.41	1.11
403	0.99	0.91	708	0.51	1.10
404	0.96	0.93	710	0.25	0.54
405	0.87	0.84	711	0.23	2.64
407	0.82	0.83	712	0.65	2.65
413	0.71	0.68	713	0.53	2.61
414	0.79	0.79	714	0.31	2.44

*See Figure 107
**First digit denotes column row number from north to south
Last two digits denote column number from east to west

LOCATION*	Displacement in North Direction (ft)	Displacement in East Direction (ft)	LOCATION*	Displacement in North Direction (ft)	Displacement in East Direction (ft)
801	0.62	1.07	1001	0.84	1.03
802	0.82	1.22	1002	0.63	1.12
803	0.75	1.28	1003	0.71	1.15
804	0.76	1.24	1004	0.55	1.35
805	0.69	1.41	1005	0.61	1.37
806	0.70	1.30	1006	0.59	1.26
807	0.37	1.01	1007	0.35	1.13
808	0.30	0.88	1008	0.32	1.35
809	0.24	0.84	1009	0.21	1.34
811	0.07	0.74	1010	0.08	1.29
812	0.34	2.57	1011	0.03	1.31
813	0.44	2.51	1012	0.74	1.31
901	0.72	1.15	1101	0.73	1.07
902	0.54	1.22	1102	0.80	1.07
903	0.68	1.32	1103	0.78	1.07
904	0.56	1.34	1104	0.59	1.43
905	0.38	1.30	1105	0.56	1.37
906	0.56	1.57	1106	0.57	1.40
907	0.29	1.10	1107	0.54	1.34
908	0.30	1.18	1108	0.92	1.50
909	0.20	1.15	1109	0.81	1.45
910	0.04	1.16	1110	1.55	1.27
911	0.06	1.03	1111	0.79	1.48
913	0.17	2.84	1112	0.85	1.38
914	0.70	2.72			

+++ HANDEC II +++

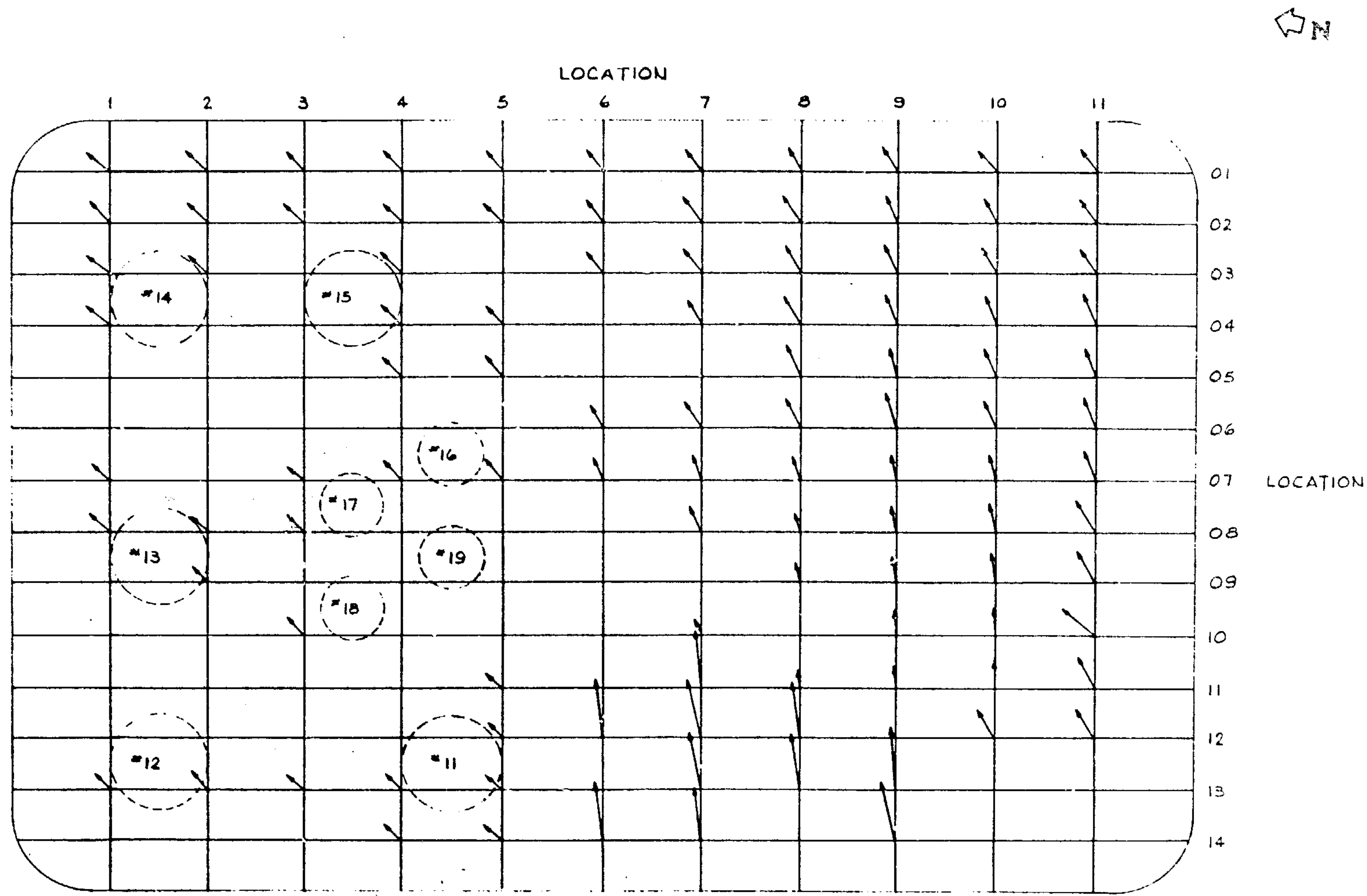

Figure 106 POST TEST SURVEY
PERMANENT HORIZONTAL DISPLACEMENT

DIRECTION
OF
BLAST

SCALE:
COLUMN GRID LINES —— 1" = 5'-0"
DISPLACEMENT ARROWS — 1" = 3'-0"

HANDEC II

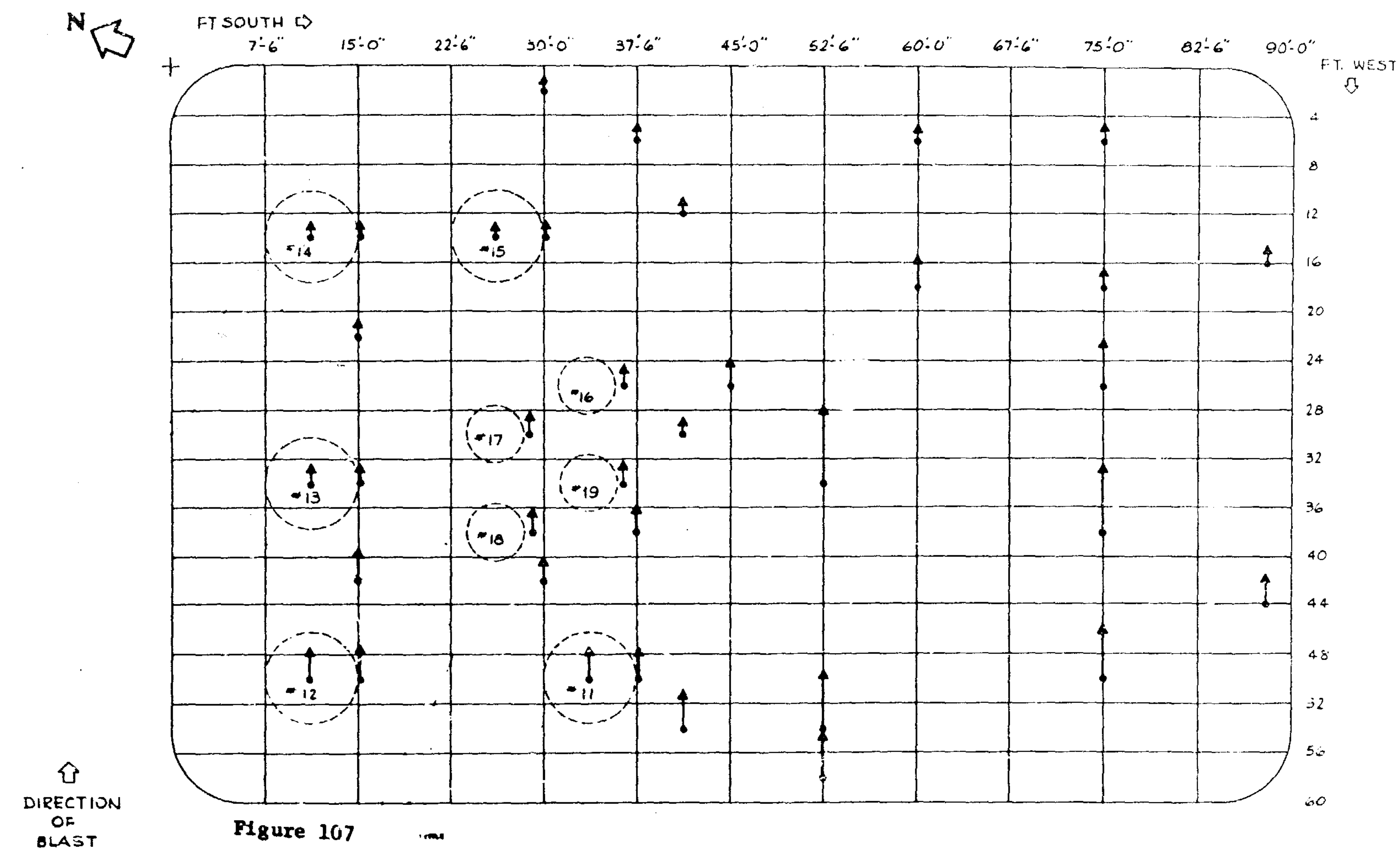

Figure 107

POST TEST SURVEY
PERMANENT VERTICAL DISPLACEMENT

SCALE:
COLUMN GRID LINES — 1" = 5'-0"
DISPLACEMENT ARROWS — 1" = 20"

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13. ABSTRACT

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A method ~~os~~ of simulating the effects of the static overpressure of the airblast and the resulting airblast-induced ground motions associated with a nuclear blast was developed by the Air Force Weapons Laboratory, and was designated High Explosive Simulation Technique (HEST). Recently, the Air Force Weapons Laboratory has been conducting tests to simulate the direct-induced ground shock from a nuclear detonation and has designated this simulation as Direct Induced High Explosive Simulation Technique (DIHEST). Proposed construction of new, harder weapon systems in rock sites made it desirable to apply the HEST and DIHEST technique to structures and research models. HANDEC I and HANDEC II were the first tests using both the HEST and DIHEST method to simulate these environments. This report describes the design and construction of both the HANDEC I and HANDEC II test facilities that were constructed in rock located near Cedar City, Utah. Design criteria are stated, some unique construction methods used are described, and recommendations are made for application to future similar projects. A complete set of design drawings and construction photographs are included. The Air Force conducted the tests and analyzed the results. This phase of the project is described in another AFWL technical report and is not included herein.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Cedar City Test Site						
SIMDEP						
HEST/DIHEST						
HANDEC I						
HANDEC II						
Rock						